PERMIAN-TRIASSIC STRATA, KUH-E-ALI BASHI, NORTHWESTERN IRAN

CURT TEICHERT,[1] BERNHARD KUMMEL,[2] AND WALTER SWEET[3]

CONTENTS

ABSTRACT. The Permian-Triassic boundary is studied in Kuh-e-Ali Bashi, northwestern Iran, in a locality situated about 8 km southeast of the classical section on the north side of the Aras River, west of Soviet Dzhulfa. Here, strata with a typical Dzhulfian fauna are overlain by a sequence of shale, sandstone, and impure limestone, 16.5 to 20.5 m thick, for which we propose the name Ali Bashi Formation. This is overlain by the Elikah Formation of Early Triassic age. The Ali Bashi Formation embraces Beds 52–61 of the stratigraphic section published by Stepanov, Golshani, and Stöcklin (1969) and is equivalent to Dzhulfian horizon 5 plus Induan horizons 1–4 of Ruzhentsev and Sarycheva (1965) on the Soviet side of the Aras River.

The fauna of the Ali Bashi Formation is described and discussed. Total number of species is about 45. New genera and species are the ammonoids *Iranites* Teichert and Kummel, n. gen., and *Shevyrevites shevyrevi* Teichert and Kummel, n. gen. and n. sp., and the conodont species *Anchignathodus julfensis* Sweet, n. sp. and subspecies *Neogondolella carinata subcarinata* Sweet, n. subsp.

The macrofauna of the Ali Bashi is of predominantly Dzhulfian aspect, but its ammonoid fauna contains distinctive elements of the Changhsingian fauna of southern China. Conodonts indicate that the Ali Bashi and at least 13.5 m of the overlying Elikah Formation belong in the *Anchignathodus typicalis* Zone, the lower boundary of which is herein established at the base of the Ali Bashi Formation, where *Neogondolella orientalis* (Barskov and Koroleva) is replaced by *N. carinata subcarinata* Sweet, n. subsp. The occurrence of *Anchignathodus isarcicus* (Huckriede) in the lower 4.5 m of the Elikah indicates a correlation of those strata with the Early Triassic Kathwai Member of the Mianwali Formation of West Pakistan and with the lower Werfen Formation of the southern Alps. The Ali Bashi does not contain any distinctively Triassic components and we conclude, therefore, that the formation is of latest Permian age, not largely Triassic as suggested by Ruzhentsev and Sarycheva for Soviet Dzhulfa and by Stepanov *et al.* for Kuh-e-Ali Bashi.

INTRODUCTION

Defining the Permian-Triassic boundary and explaining the significant turnover of invertebrate faunas at this stratigraphic level have long been important problems in earth history. There have been countless published contributions centered on discussions of this boundary and its significance in the history of life. In 1958, during an informal discussion of this problem, Teichert and Kummel noted that, whatever data they

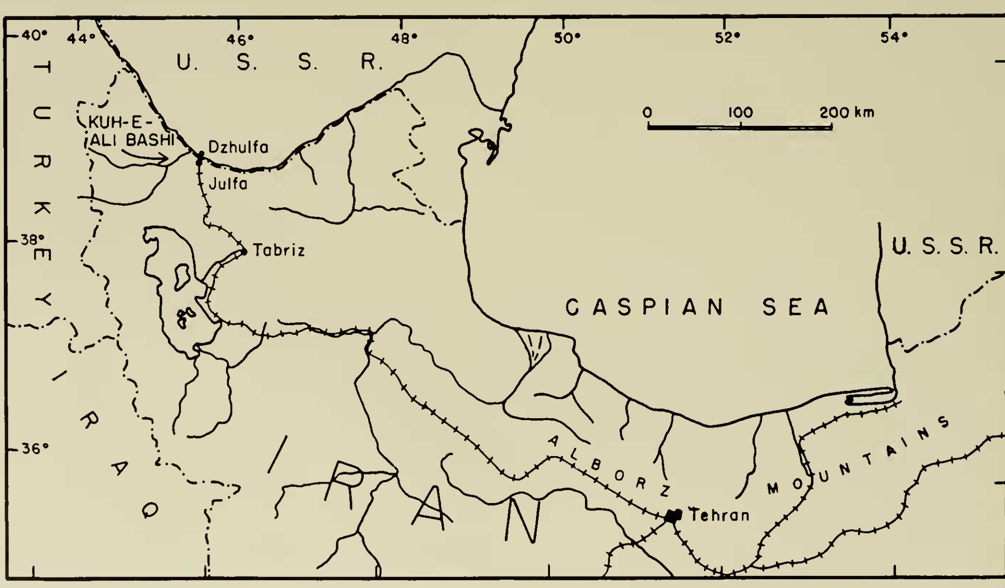
[1] University of Kansas, Lawrence, Kansas
[2] Harvard University, Cambridge, Massachusetts
[3] Ohio State University, Columbus, Ohio

contained, most published reports were based on old, classical, original geologic and stratigraphic studies of areas known to contain marine Late Permian and Early Triassic strata in superposition. These are the Salt Range of West Pakistan, Kashmir, the Dzhulfa region of the USSR, and East Greenland. They then agreed that the time had come to reinvestigate in a fully modern stratigraphic, sedimentologic, and paleontologic sense these so-called classical areas to determine just what were the facts. Since that time they have followed this plan, the first investigated being of the marvelous sections in the Salt Range of West Pakistan. Their final report on this work (Kummel and Teichert, 1970) encompassed the work of several colleagues who are specialists on various invertebrate and plant groups. After their original field work in the Salt Range of West Pakistan, they were privileged to visit the Guryul Ravine in Kashmir (briefly reported on by Teichert, Kummel, and Kapoor, 1970), Kap Stosch in East Greenland (Teichert and Kummel, 1971 and 1973b), and the Julfa region of northwestern Iran, the objective of this report (Text-figs. 1, 2).

Field studies in the Kuh-e-Ali Bashi area of northwest Iran were carried out by Teichert and Kummel in July of 1968. These two authors are thus responsible for measurement and description of the sections discussed in this report; for collection of the fossils newly described herein; and for collation of reports received from various specialists to whom portions of the collections were submitted for study. Bulk samples collected by Teichert and Kummel proved to contain numerous conodonts, and it has been Sweet's responsibility to prepare these collections, describe them, and assess their stratigraphic significance. Because of this division of responsibility, it is to be understood that all statements pertaining to conodonts, including authorship of several new names, are to be credited to Sweet.

A few notes on the spelling of place names are in order. The river that divides the outcrop area in the USSR from that in Iran, discussed in this report, is the Araxes River of classical times, named after a mythical king of the ancient Greeks. Present spelling is Araks in Russian and Aras in Persian. We are here using the Persian version, Aras River.

Julfa is the name of a border settlement



Text-figure 1. Sketch map of northwest Iran.

Text-figure 2. Sketch map of Julfa region and Kuh-e-Ali Bashi.

on the Iranian side of the Aras, where a road and a railroad cross from Iran into Soviet territory. The Soviet counterpart on the north side of the Aras is a settlement whose name is correctly transliterated as Dzhulfa. It should be understood that wherever we use the name Julfa in the present paper, we refer to the area south of the Aras River in Iran and where we refer to Dzhulfa, we mean the Soviet area north of the river.

It should be noted that the *Dzhulfian Stage* has its type locality on the Soviet side of the river and that its name should therefore be spelled as indicated here. However, the Julfa beds, as used by Stepanov *et al.* (1969) and in this report, derive their name from Iranian Julfa. The Julfa beds are considered to be of Dzhulfian age.

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HISTORY OF RESEARCH ON THE PERMIAN-TRIASSIC SEQUENCES OF TRANSCAUCASIA AND NORTHWESTERN IRAN

Research on the Permian-Triassic deposits in Transcaucasia began as early as 1878, whereas in Northwestern Iran such investigations were not initiated until 1966. It is therefore advisable to deal separately with the history of research in the area north and south of the Aras River.

Transcaucasia

The history of investigations of the Permian and Triassic deposits of Transcaucasia has been exhaustively described by Shevyrev in Ruzhentsev and Sarycheva (1965). The general part of this book has been made available in English translation by D. A. Brown as Publication No. 117, Geology Department, Australian National University, Canberra, 1968. With the gracious permission of Professor Brown, the following account leans heavily on this translation. Our account is concerned more especially with the stratigraphic succession in the area immediately west of Dzhulfa, where the Aras River flows through a narrow and steep gorge. The stratigraphy and paleontology of the rocks exposed on the northern, Russian side of this gorge have been the object of investigation for nearly a century. The section was first studied by Abich (1878), who recognized the following four stratigraphic units in descending order:

4. Laminated limestones with *Pecten tortilis* Semenov;
3. Dark gray laminated limestones;
2. Limestones with layers of marl, containing numerous brachiopods;
1. Limestones and marls with brachiopods and ammonoids.

From the lowermost two units, Abich obtained a large collection of fossils from which he described 39 species and varieties of brachiopods, 11 species and varieties of corals, gastropods, bryozoans, and crinoids, 17 species of nautiloids, and 6 species of ammonoids. He noted the mixed character of the faunas from these units, which he divided into four groups of species characteristic of different ages.

Abich believed the first group to include brachiopods known from the Carboniferous deposits. Brachiopods of the second group he found to be similar to species from the Zechstein (Upper Permian). In the third group, he recognized several ammonoids resembling *Ceratites* (*Proptychites*) *lawrencianus* de Koninck, then known from Triassic deposits of the Salt Range. Finally, in the fourth group, he included species known only from deposits of the Dzhulfa area. From the predominance of species of the first group in this complex faunal assemblage, Abich considered the fauna that he had described to be Early Carboniferous in age. Moreover, he first noted in these deposits the common occurrence of ammonoids with ceratitic and goniatitic sutures.

In the year following the publication of Abich's work, Möller (1879) reevaluated several of the species of brachiopods and cephalopods described by Abich and, on the basis of his restudies, raised the age of the fauna to Early Permian. This revision was based particularly on presence of the ammonoids identified by Abich as *Goniatites striatus* Martin, which were placed by Möller in a new species, *G. abichianus* (now *Pseudogastrioceras*).

Abich's collections were further studied by Mojsisovics (1879). In one sample, this author found an ammonoid that he believed to be a respresentative of *Tirolites*, a genus widely distributed in the Campilian deposits of the eastern Alps. Mojsisovics further believed that the species described by Abich as *Pecten tortilis* was closely related to *Avicula* (now *Claraia*) *clarae* (Emmrich), a bivalve widely distributed in rocks of Early Triassic age. According to Mojsisovics, these fossils clearly indicated an Early Triassice age. It is now clear that the poorly preserved ammonoid specimen that Mojsisovics identified as *Tirolites* actually belonged to the genus *Paratirolites*, established by Stoyanow in 1910. Thus Mojsisovics was the first to suggest presence of rocks of Permian as well as of Triassic age in the section along the Aras Gorge west of Dzhulfa, although most facts of physical stratigraphy and of the stratigraphic distribution of the known species remain to be described.

Griesbach (1880), in his descriptions of the fossils from the Niti Limestone of the Himalayas, expressed the opinion that the ceratites described by Abich were close to, or identical with, *Otoceras*, a genus that he regarded as characteristic of beds transitional from Permian to Triassic.

Karpinsky (1890), in his monograph on the Artinskian ammonoids, expressed the view that the Dzhulfa beds in all probability were not only younger than the Artinskian beds but also younger than the Upper Productus limestone of the Salt Range. However, in his correlation table (Table D), he placed the Dzhulfa beds at the same level as the Upper Productus limestone, that is, at the top of the Permian system. Waagen (1891) believed that the Dzhulfa beds could be divided into a lower part containing brachiopods and *Gastrioceras*, which was of Late Permian age, and an upper part containing *Otoceras*, which was transitional to the Triassic.

In subsequent years, Mojsisovics and Diener contributed greatly to the problem of correlation of the Dzhulfa beds. Mojsisovics (1892) concurred with Griesbach's view that the Himalayan otoceratid fauna occupies the lowest position in the Triassic system. At the same time, however, he believed that the so-called otoceratid fauna of Dzhulfa was older. He pointed out that the Himalayan forms possess clearly differentiated and well-expressed so-called axial lobes. In the Dzhulfa species of so-called *Otoceras*, on the other hand, he observed that the lobes and saddles near the umbonal region are not differentiated, which he took to indicate a lower degree of evolutionary development and therefore a Late Permian age.

Diener, in several publications, resolutely supported this view on the different ages of the Himalayan and Dzhulfa "*Otoceras*." He also pointed to the coexistence of these forms at Dzhulfa with a rich assemblage of definitely Paleozoic brachiopods and nautiloids. He correlated the Dzhulfa beds with the Upper Productus limestone of the Salt Range, the Productus shales of the Himalayas, and the Bellerophon beds of the eastern Alps. He correlated the higher limestones in the Dzhulfa section containing *Pseudomonotis* sp. cf. *P. clarae* and ?*Tirolites* with the Lower Ceratite limestone, the Ceratite marls, and the Ceratite sandstone of the Salt Range, with the "*Otoceras*" and *subrobustus* beds of the Himalayas, and with the Scythian of the eastern Alps.

At the end of the last century, Frech and Arthaber (1900) visited the Dzhulfa Gorge but had very little time to undertake detailed stratigraphic investigations. From the large collection that they made from talus of the Dzhulfa beds, Arthaber (1900) identified and described 46 species. Both authors came to the conclusion that the Paleozoic beds of the Dzhulfa section may be correlated with the lower part of the Upper Productus limestone of the Salt Range and placed them above the Artinskian Stage and the Fusulina beds of Sosio (Frech and Arthaber, 1900: 295). Frech (1901: 568) repeated his view that the Dzhulfa beds contain one of the best known faunas of the early Late Permian in the "pelagic" development.

In the higher part of the Dzhulfa section, Frech and Arthaber could not find any fossils and came to the conclusion that those identified by previous workers as "*Avicula*" or "*Pseudomonotis*" cf. *clarae* and as ?*Tirolites* could not have come from this locality.

Chernyshev (Tschernyshew) (1902: 419), in his well-known monograph on the Late Carboniferous brachiopods of the Urals and the Timan, erroneously correlated the Upper Productus limestone of the Salt Range with the Artinskian Stage of the Urals. Therefore, he also believed the Permian beds in the Dzhulfa area to be of Early Permian age.

Chernyshev, like other authors before him, had called attention to the necessity of obtaining more detailed information on the stratigraphy and the distribution of the fossil faunas in the sequence. Such information was not forthcoming until A. A. Stoyanow went to the area in 1908 and worked out the first detailed stratigraphy and faunal sequence of the section. Because of the considerable importance of Stoyanow's work, his scheme of subdivision of the Dzhulfa section is given here in condensed form (Stoyanow, 1910):

Unit	*Description*	*Thickness (meters)*
15	Gray marls, separated under the name "pelecypod beds," with "*Avicula*" sp. cf. *A. clarae* (Emmrich)	6
14	Alternate white marls and limestones without fossils	56
13	Red marls, in the lower part with indeterminate fossil remains, and in the upper with "*Xenodiscus*" *radians* Waagen, "*X.*" sp. aff. *X. kapila* Diener, "*X.*" sp. cf. *X. rotula* Waagen, "*X.*" (*Paratirolites*?) *mojsisovicsi* Stoyanow, "*Stephanites*" sp., "*S.*" *waageni* Stoyanow, *Paratirolites kittli* Stoyanow, "*Balatonites*"? sp. cf. *B. euryomphalus* Benecke (zone of *Paratirolites kittli*)	30
12	White marls without fossils	1
11	Red marls, forming the zone of "*Popanoceras*" *tschernyschewi* Stoyanow, with "*P.*" *tschernyschewi* and "*Gastrioceras*" *abichianum*	3.5
10	White marls without fossils	10
9	Red marls, divided into two parts: a) lower, with crinoids *Cyathocrinus*? and with "*Gastrioceras*" *abichianum*, and b) upper, with "*G.*" *abichianum*	15
8	Reticularid zone with *Reticularia indica* Waagen, *R. pulcherrima* Gemmellaro, *R. convexiuscula* Gemmellaro, *R. waageni* Loczy, *Spirigera protea*, "*Gastrioceras*" *abichianum*	10
7	Cephalopod zone with "*Otoceras*" *trochoides* Abich, "*Gastrioceras*" *abichianum* Möller, *Orthoceras transversum* Abich, *O. obliqueannulatum* Waagen, *O. cribrosum* Geinitz, *O. bicinctum* Abich, *O. lopingense* Stoyanow, *Nautilus hunicus* Diener, *Spirigera protea*	3
6	Zone of *Spirigera protea* Abich with *Orthotetes eusarcos* (Abich) and *Strophalosia* sp.	1.5
5	Zone of *Productus djulfensis* Stoyanow with *Orthis indica* Waagen and *Marginifera spinosocostata* (Abich)	1
4	Crinoidal reef with *Poteriocrinus*? and *Tschernyschewia typica* Stoyanow	2.5
3	Polyzoan reef with *Polypora fastuosa* de Koninck and *Notothyris djoulfensis* (Abich)	3
2	Zone of *Notothyris djoulfensis* (Abich) with *N. nucleolus* (Kutorga)	1
1	Zone of *Productus intermedius* Abich with *Tschernyschewia scabricula* (Martin), *T. humboldti* (d'Orbigny), *Marginifera helica* (Abich), *Camarophoria* sp. cf. *C. solitaria* Gemmellaro, *Orthotetes armeniacus* Arthaber, *O. peregrinus* (Abich)	2
	Total Thickness	145.5

Stoyanow dated his units 1 to 11 inclusive as Early Permian because he regarded the many species of brachiopods as closely related to the species in the Schwagerina limestone and Artinskian deposits of the Ural Mountains. He believed the upper part of unit 13 to be Triassic because of the occurrence of *Paratirolites* and other Triassic genera. The unfossiliferous unit 12 and the lower unfossiliferous part of the red marls of unit 13 he regarded as Late Permian in age. Thus, Stoyanow regarded the lower, highly fossiliferous part of the Dzhulfa section as Lower Permian, separated from earliest Triassic rocks by a few meters of unfossiliferous marls to which he assigned a Late Permian age.

Much later, Stoyanow (1942) reconsidered several of his conclusions. More particularly, he raised the age of the beds with the Paleozoic fauna to Late Permian. Directly above the zone of *Popanoceras tschernyschewi* in unit 11, he determined the presence of the Triassic zone of *Meekoceras-Hedenstroemia,* and in this way, believed that he had established the existence of a stratigraphic break at the boundary between the Permian and Triassic.

Only two years after Stoyanow had completed his investigations in the Dzhulfa area, two French geologists, P. and N. Bonnet, began to study the stratigraphy of the Paleozoic and Mesozoic deposits of Transcaucasia and described their results in a large number of mostly short reports. It is unnecessary for our purposes to record in detail the many opinions that were put forward by them in these various publications. However, their last monographic work (Bonnet and Bonnet, 1947), issued after the death of N. Bonnet, must be considered in somewhat greater detail because it was in this work that they presumably presented their latest and most mature opinions on the succession in the Dzhulfa Gorge and its age. These writers divided what they believed to be the Permian deposits in the Dzhulfa section in the following way:

Lower Permian. Shales and limestones 7–8 m thick:

a) beds with corals, crinoids, polyzoans, and brachiopods—*Amplexus abichi* Waagen and Wentzel, *Zaphrentis leptoconica* Abich, *Poteriocrinus* sp., *Polypora fastuosa* de Koninck, *Notothyris djoulfensis* (Abich), *N. nucleolus* (Kutorga);

b) beds with brachiopods—*Dalmanella indica* Waagen, *Productus hemisphaericum* Kutorga, *Marginifera spinosocostata* (Abich), *M. intermedia helica* (Abich), *Lyttonia nobilis* Waagen, *Richthofenia? sicula* Gemmellaro.

Middle Permian. Limestones and shales, 15 m thick, with brachiopods—*Productus subcostatus* Waagen, *Marginifera intermedia helica, Martinia semiplana* Waagen, *Reticularia waageni, R. indica* Waagen, *R. lineata* Martin, *R. pulcherrima* Gemmellaro, *R. convexiuscula* Gemmellaro, *Spirigera protea* Abich, *S. felina* Arthaber, *S. abichi* Arthaber.

Upper Permian. Limestones and shales 20–25 m thick (lower otoceratid beds) with *Orthoceras annulatum* Sowerby, *O. bicinctum* Abich, *O. transversum* Abich, *Nautilus cornutus* Golovk., *N. parallelus* Abich, *Pleuronautilus pichleri* Hauer, *P.* sp. cf. *P. verae* Arthaber, *Coelonautilus dorsoplicatus* (Abich), *Goniatites abichianus* Möller, *Otoceras djoulfense* (Abich), *O. intermedium* (Abich), *O. tropitum* (Abich), *O. trochoides* (Abich), *Hungarites pessoides* (Abich), and brachiopods of the genera *Marginifera, Reticularia,* and *Spirigera.*

The total Permian section recorded by Bonnet and Bonnet was 42–48 meters thick.

In the same publication, the authors also gave a description of what they believed to be deposits of Triassic age in the same section and described them as follows:

Lower Triassic

I. Lower Werfenian substage. Marly limestones about 250 m thick.
   1. Red limestones with several horizons of gray marl 10 m thick, with crinoids, corals, and rare productids.
   2. Red limestones 25–30 m thick with problematical cephalopods.
   3. Red laminated limestones 3–4 m thick, which are divided into two parts:
      a) a lower part with *Xenodiscus* (*Kashmirites*) *dimorphus* Waagen, *X.* (*K.*) *armatus* Waagen, *X.* (*K.*) *acuteplicatus* Waagen, *X. radians* Waagen, *X. himalayanus* Griesbach, *X. kapila* Diener, *X. mojsisovicsi* Stoyanow, *Goniatites abichianus* Möller;
      b) an upper part with *Paratirolites dieneri* Stoyanow (cf. *Danubites nivalis* Diener), *P. kittli* Stoyanow, *Stephanites? waageni* Stoyanow.

II. Upper Werfenian substage
   4. Gray laminated marly limestones with uneven surface, containing bivalves—*Pseudomonotis* (*Claraia*) sp. cf. *P. clarae, P.* (*C.*) *himaica* Bittner, *P.* (*C.*) *decidens* Bittner and rare undetermined

ammonoids. These limestones are correlated with the *Hedenstroemia* beds of the Himalaya.

Bonnet and Bonnet continued to insist that species of *Otoceras* similar to the Himalayan representatives of this genus existed in the Dzhulfa section. It remained for Spath (1930, 1934) and for Ruzhentsev (1959, 1962, 1963) to clear up the distinctions between the Permian and the Triassic otoceratids. The Permian forms were divided into a number of genera by Spath and Ruzhentsev and shown to belong to a new family Araxoceratidae Ruzhentsev, the members of which are distinguished from the Otoceratidae by differences in form of shell and less complex sutures. On the basis of an analysis of the various faunas concerned, Spath in 1934 regarded the Dzhulfa beds as younger than the Upper Productus limestone of the Salt Range. The zone of *Paratirolites kittli* Stoyanow (the upper part of unit 13 of Stoyanow, 1910) was placed by Spath (1934) and by Kummel (1957) in the Upper Scythian, and Kummel correlated it with the upper *Owenites* beds or the zone of *Anasibirites*. In the years following the investigations of Stoyanow and the Bonnets, the Upper Paleozoic deposits of Transcaucasia were studied by Yakovlev (1931, 1933, 1934). As a result, in the Dzhulfa section the Permian System was made to include the sequence of limestones, 150 m thick, which previous authors usually considered as Middle and Upper Carboniferous. This was confirmed mainly by the study of Foraminifera, corals, and Bryozoa.

The Late Permian age of the Dzhulfa beds was also confirmed by studies made by Varentsov and Laliev (1939), Paffengolts (1948, 1959), Arakelyan (1951, 1952a, b), Azizbekov and Paffengolts (1952), Sadykov (1954), Azizbekov (1960, 1961), Ilina (1962), Arakelyan *et al.* (1964), and others.

Miller and Furnish (1940) pointed out that there is little in common between the Permian ammonoids of Transcaucasia on the one hand and of the Salt Range and Himalayas on the other. Nevertheless, in their correlation table, they correlated the Dzhulfa beds with the Upper Productus limestone ("Chideru Group") of the Salt Range and the Chitichun I and Kuling beds of the Himalayas.

Schenck *et al.* (1941) were the first to suggest the name Dzhulfian Stage for which the type section was the Permian sequence in Transcaucasia. They also suggested the name Punjabian Stage as typified by the Upper Productus limestone of the Salt Range. However, it must be pointed out that the name Punjabian had already been preoccupied by Noetling (1901) for the Lower Permian deposits of the same locality. When Glenister and Furnish (1961) suggested that the uppermost stage of the standard scale of the Permian system be named the Dzhulfian with its type locality in the Aras Gorge, they considered this stage to be the approximate equivalent of their *Cyclolobus* Zone, despite the fact that this genus had not, at that time, been reported from the Dzhulfa section.

During the 1950's and 1960's, numerous investigations were carried out by many authors in Transcaucasia, especially in the area of the Nakhichevansk ASSR as summarized by Shevyrev in Ruzhentsev and Sarycheva (1965). These contributed much to the more detailed knowledge of Permian and Triassic deposits in this area but had little special bearing on the problem of the Permian-Triassic boundary as such. According to Sadykov (1953), the Lower Triassic in this area begins with reddish argillaceous and sandy limestones, containing *Paratirolites kittli* at the base, which is 2 to 5 m thick, and is thus clearly identical with the upper part of unit 13 of Stoyanow (1910). It is interesting to note that Sadykov also mentions solitary corals and rare brachiopods from this unit. Apart from this, Sadykov must have had a mixed fauna at his disposal because he also mentions *Kashmirites* as occurring together with *Paratirolites*. However, *Kashmirites*, according to Spath (1934) and Kummel (1957), is characteristic of Middle Scythian strata rather than Lower ones.

Rostovtsev (1958), also working in the same area, related that Upper Permian limestones with *Composita protea* are overlain without break by a unit of light gray and pink limestone, 8 m thick, with *Otoceras* sp. aff. *O. woodwardi* corresponding to the *Otoceras* Zone of the Himalayas. In this unit, there are rare *Productus* sp., *Athyris* sp., and *Pseudogastrioceras abichianum* (Möller). Above the beds with *Otoceras,* according to Rostovtsev, the most characteristic Lower Triassic bed of Transcaucasia consists of red marly limestone, from 5 to 20 m thick, and contains a rich assemblage of ammonoids, the composition of which, in all its variety, clearly indicates association with the Indian Province of the Tethys. Characteristic ammonoids of this unit were said to be *Paratirolites kittli, P. mojsisovicsi, P. waageni, Kashmirites stoyanowi, Flemingites* sp., and others. In the opinion of Rostovtsev, this faunal assemblage corresponds to the Scythian and basal Campilian stages of the Lower Triassic, equivalent to the *Ophiceras, Meekoceras,* and basal *Hedenstroemia* zones of the Himalaya.

In the light of present knowledge, these studies must have been based on mixed collections from more than one biostratigraphic zone. Apparently, Rostovtsev perpetuated the error of so many of his predecessors by mistaking one of the genera of the Araxoceratidae of the Upper Permian in the Dzhulfa section for *Otoceras woodwardi* or a closely related form of the lowest Triassic beds of the Himalaya. Up to this point, it seems that Sadykov (1953) was the only geologist to have recorded an occurrence of Triassic ammonoids in the same bed with brachiopods and corals of a Paleozoic type. However, his listing of the stratigraphic conditions and the occurrence of the faunas were far from clear.

Up to this point, as Shevyrev (*in* Ruzhentsev and Sarycheva, 1965) so succinctly summarized, there is

> "quite clear evidence of the great confusion in the ideas of individual investigators on the stratigraphy of the Upper Permian and Triassic deposits of Trans-Caucasis and, primarily, on the boundary between these systems. Some of the authors place the Permian-Triassic boundary at the base of the red limestones with *Paratirolites* (Sadykov, 1953; Stoyanov, 1910), others lower this boundary considerably to the base of the so-called "otoceratid" zone (Rostovtsev, 1958). Especially mobile were the views of Bonnet, who was sometimes ready to agree with Stoyanov's opinion about placing the boundary at the base of the limestones with *Paratirolites,* sometimes to lower it 25 to 30 m to the base of the unfossiliferous calcareous-argillaceous sequence (Bonnet, 1912a, b), and sometimes inclined to place it even lower at the "otoceratid" zone (Bonnet, 1919). So far, there is no single opinion among investigators about the age of the individual faunal horizons of the Dzhul'fa section nor on their correlation with the Permian and Triassic deposits of other regions of the globe."

(Shevyrev *in* Ruzhentsev and Sarycheva, 1965: 19. English translation, Brown, 1968: 15.)

This statement by Shevyrev is probably a fair summation of the state of knowledge in regard to the Permian-Triassic boundary in the Dzhulfa section and other parts of Transcaucasia toward the end of the 1950's. It must have been about this time that a large group of geologists and paleontologists from the Paleontological Institute of the Academy of Sciences of the USSR began to organize a special study of the Paleozoic and Triassic sections in Transcaucasia. These studies were not concentrated on the Dzhulfa section only, but were extended to 20 additional localities in the Nakhichevansk ASSR and in the Armenian SSR. The results of these investigations were published in book form in 1965 as volume 108 of the Transactions of the Paleontological Institute of the Academy of Sciences of the USSR under the editorship of V. E. Ruzhentsev and T. G. Sarycheva. It is in this book that the main features of the Permian-Triassic sequence in the Dzhulfa section and its fossil content were described in detail for the first time.

The Soviet geologists found that in the entire area, Permian deposits rest transgressively with insignificant angular unconformities, or without visible unconformity on Devonian and Lower Carboniferous rocks of various ages. The base of the Permian is marked almost invariably by a thin, basal conglomerate. Apparently, the entire Permian system is represented from the Lower Permian to the top of the Upper Permian, but since the emphasis of the report is on the Upper Permian and Lower Triassic, the Lower Permian deposits are not described. Total thickness of the Permian deposits varies from 400 to 900 m. The Upper Permian Series is subdivided into a lower Guadalupian Stage and an upper Dzhulfian Stage. The rocks of the Guadalupian Stage are subdivided into two "horizons," called Gnishik Horizon and Khachik Horizon (Text-fig. 3). These "horizons" are, at present, best regarded equivalents of four stratigraphic formations in terms of American stratigraphic procedures. The entire sequence is highly fossiliferous, and many of the species are described —or at least illustrated—in the Russian report. However, since we have not studied in detail the equivalents of these rocks on the Iranian side of the Aras River, we do not further consider them here.

The Dzhulfian Stage is subdivided into informally named units called "beds."

Unit	Description	Thickness (meters)
5	Beds with *Phisonites* and *Comelicania*	4.5
4	Beds with *Vedioceras* and *Haydenella*	0.2–19
3	Beds with *Araxoceras* and *Oldhamina*	8.0
2	Beds with *Araxilevis*	12.0
1	Beds with *Codonofusiella* and *Reichelina*	2.0–5.5

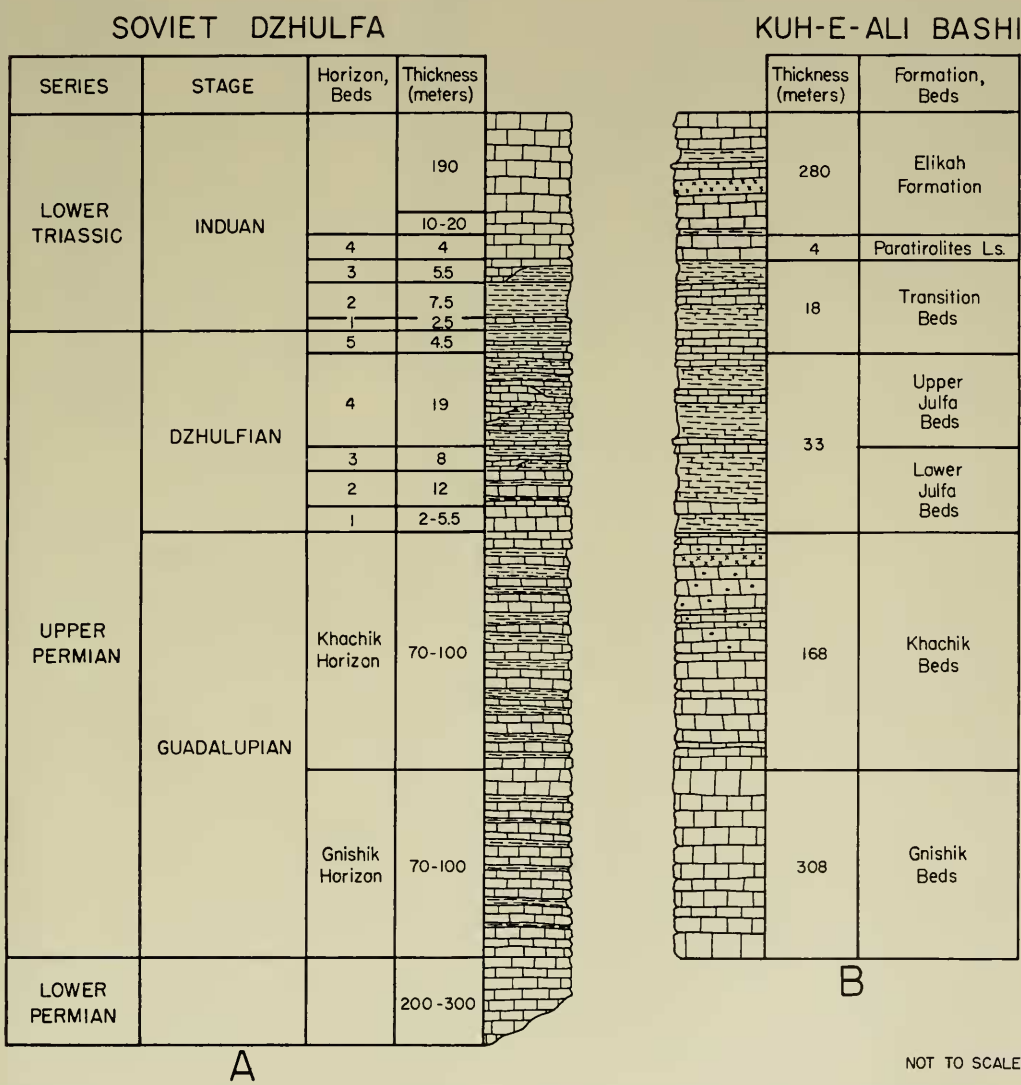
Thus, the entire sequence of rocks representing the Dzhulfian Stage may range from about 27 to about 50 m. It seems that this sequence represents one single formation in the American sense of this term. On the Iranian side we refer to it, with the exception of unit 5, simply as Julfa beds, for the entire formation is extremely fossiliferous and especially rich in brachiopods. Rugose corals, nautiloids, and ammonoids are also richly represented in addition to fusulines in the lower part (unit 1). The nautiloids have been described by Teichert and Kummel (1973).

The rocks overlying the Dzhulfa beds were assigned by the Russian authors to a stratigraphic unit that they called the Induan Stage. It appears from the general discussion that the "Induan" Stage corresponds to the lower part of the Scythian Stage in the conventional sense. The lower part of the rock sequence of the "Induan" Stage was subdivided into informally named "beds," and since it is this part of the section on which we concentrated our investigations on the Iranian side of the Aras River, we quote the observations in the Russian report in somewhat greater detail. These subdivisions are as follows (Text-fig. 4):

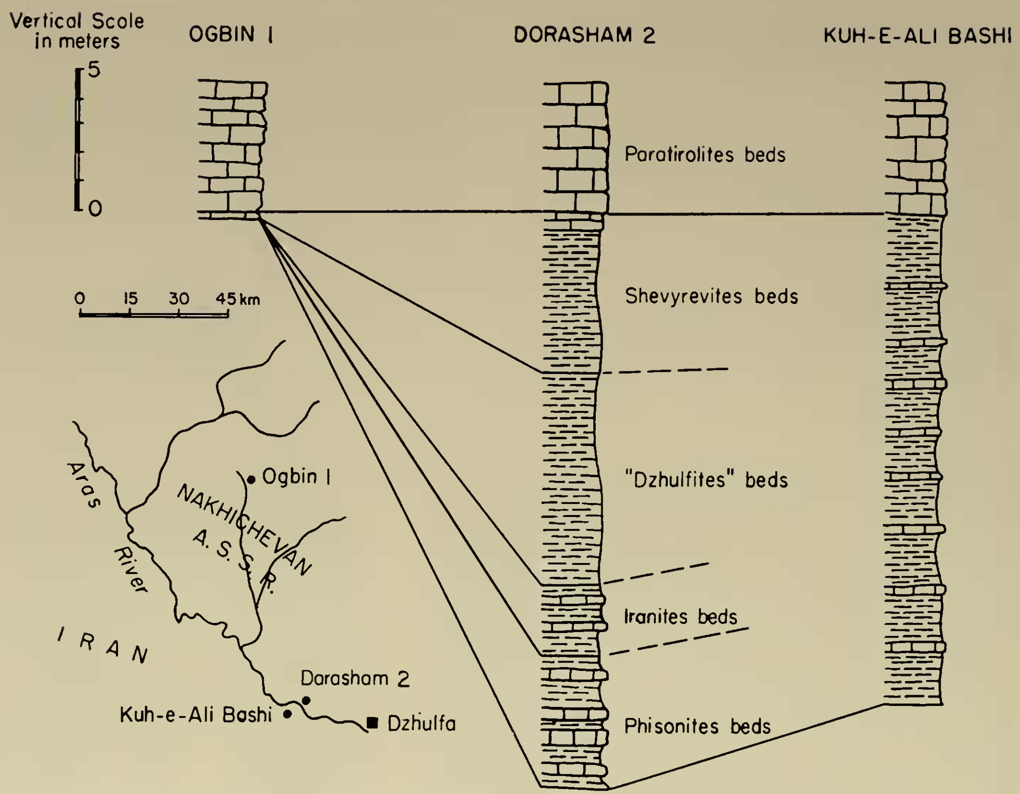
Unit	Description	Thickness (meters)
4	Beds with *Paratirolites*. Limestones, reddish brown, finely laminated, in places nodular argillaceous, with thin layers of brown shale	4.5–7.5
3	Beds with *Bernhardites*. Shales and limestones similar to the underlying beds, with *Bernhardites radiosus*, *B. nodosus*, and *Pseudogastrioceras abichianum*	5.5
2	Beds with *Dzhulfites*. Shales, brownish, greenish, or dark gray in color, with layers of varicolored marly limestones containing *Dzhulfites spinosus* and *D. nodosus*	7.5
1	Beds with *Tompophiceras*. Dark gray shales, alternating with light gray marly limestones; in	

the middle part of the beds is an horizon (0.5 m) of brown shales and limestones. *Tompophiceras transcaucasium* occurs here 2.5

Thus, this part of the "Induan" has, in the Dzhulfa section, a thickness of at least 20 m. From unspecified stratigraphic levels within these four numbered beds, the following species, possibly collected from float, are cited: Rugosa—*Plerophyllum dzhulfense*, *P. differentiatum*, *P. armenicum*, *P. cuneatum*, *Pleramplexus leptoconicus*, *P. minimus*; Ammonoidea–*Paratirolites kittli*, *P. waageni*, *P. vediensis*, *P. trapezoidalis*, *P. dieneri*, *Abichites stoyanowi*, *A. mojsisovicsi*, *A.*



Text-figure 3. Generalized stratigraphic column of Permian and Triassic formations in (A) Dzhulfa region, Transcaucasia (data from Ruzhentsev and Sarycheva, 1965) and (B), at Kuh-e-Ali Bashi, Julfa region, northwest Iran (data from Stepanov, Golshani, and Stöcklin, 1969).



Text-figure 4. Correlation of Ali Bashi Formation between Ogbin, Dorasham 2, and Kuh-e-Ali Bashi.

abichi; Brachiopoda—*Enteletes dzhagrensis, Orthotichia parva, Orthotetina* sp., *Spinomarginifera pygmaea, Haydenella kiangsiensis, H. minuta, Terebratuloidea* sp., *Araxthyris ogbinensis, A. araxensis minor;* nautiloids, small foraminifers, and bryozoans.

The authors, judging from the ammonoids, concluded that this part of the Triassic section belongs to the basal "Induan" Stage. They further stated that the beds with *Paratirolites* in Dzhulfa Gorge are conformably overlain by light gray, thinly bedded marly limestone containing the bivalves *Claraia stachei* and *C. aurita.* Higher up follow gray, thinly laminated, "fucoid" limestones up to 150 m thick, which are replaced upwards in the section by massive, commonly oolitic limestones having a thickness of 40 m. From these upper limestones, the bivalves *Eumorphotis, Velopecten,* and *Myophoria* are reported.

The chapter on the Triassic rocks is followed by one on the composition and development of the following fossil groups: fusulinids, Sphinctozoa, tabulate corals, rugose corals, nautiloids, ammonoids, bryozoans, brachiopods, trilobites, ostracods, fishes, algae—in that order. For each group, a detailed discussion of the occurrences of species of Guadalupian, Dzhulfian, and "Induan" age is given, and for each group a detailed list of species is compiled indicating the occurrence of individual species in the localities studied by the authors.

In the two following chapters are discussions of both biostratigraphic conclusions and the reasons for the change in the organic world at the boundary between the Paleozoic and Mesozoic eras. We are discussing the authors' opinions in these fields elsewhere in this paper to the extent that they have a bearing on our own studies and conclusions.

A greater part of the book (p. 135–432, text–figs. 4–59, plates 1–58) is given to systematic paleontology, containing descriptions of many new species and some new genera. In addition, numerous species are illustrated on the plates which have not been described in the text, but which had been named and described previously. Later in this paper we refer to those species whose representatives we found on the Iranian side of the Aras River.

All in all, the publication edited by Ruzhentsev and Sarycheva represents a monumental step forward in our understanding of the Permian and Triassic systems and their interrelationships in Transcaucasia and especially in the Dzhulfa area.

Tozer (1969) reinterpreted the evidence presented by Ruzhentsev and Sarycheva and their collaborators and concluded that the boundary between the Permian and Triassic Systems in the Dzhulfa area should be placed at the top of the *Paratirolites* beds. Furnish and Glenister (1970) also regarded *Paratirolites* as marking uppermost Permian.

Rostovtsev and Azaryan (1971a) restudied some of the Permian-Triassic sections in Transcaucasia. They came to the conclusion that in the Dzhulfa section all beds below the thin-bedded limestone with *Claraia* (unit G) are of Permian age. They quoted Kummel's (misspelt Kamme in the English translation) reinterpretation of Shevyrev's "*Tompophiceras*" and "*Bernhardites radiosus*" and listed as *nomina nuda* the generic names *Iranites* and *Shevyrevites*, which are being established in the present paper. For the beds from the base of the *Phisonites* Zone to the top of the *Paratirolites* Zone the authors propose a new chronostratigraphic term, Dorasham Stage. This would appear to be a synonym of the Changhsingian of Furnish and Glenister (1970).

NORTHWESTERN IRAN

At the time of the publication of the volume edited by Ruzhentsev and Sarycheva in 1965, nothing was known about the geology of the country immediately south of the Aras River opposite the Paleozoic and Triassic outcrops on the Soviet side to the north. The geological map of Iran, 1:2,500,000, published by the National Iranian Oil Company in 1959, shows only Triassic, no Permian, rocks in this area. This information was, no doubt, based in part on the map published by Bonnet and Bonnet (1947), who showed the presence of Triassic rocks south of the Aras River. No information on the geology of this part of Iran was available in the files of the Geological Survey of Iran.

The Bonnets' map and their descriptions, published in 1947, suggested to Teichert the possibility that Permian rocks might also be present on the Iranian side of the Aras River. On 16 February 1966, Teichert wrote to N. Khadem, Director of the Geological Survey of Iran, that "I believe that a stratigraphic section similar to that on the Russian side may exist on the Iranian side near Julfa," which is the counterpart to the Russian Dzhulfa on the north side of the Aras River. In the same letter, Teichert explained his general interest in problems of the Permian-Triassic boundary on a worldwide basis and inquired about the possibility of a reconnaissance visit to this area with logistic support from the Geological Survey of Iran, for the purpose of ascertaining the presence of such a Permian-Triassic section on the Iranian side of the border. With the kind intervention of Mr. Khadem, permission for Teichert to visit this border area was granted by authorities, and the date of 5 October 1966 was later agreed upon for the beginning of this reconnaissance visit, which was to last only a few days. Two or three days before that date, Teichert was informed in Teheran that he would be accompanied in the field by Helmut Flügel, of the University of Graz, Austria, and by D. L. Stepanov, of the University of Leningrad. Stepanov had then recently joined a United Nations advisory team working with the Geological Survey of Iran. Teichert, Flügel, and Stepanov met in Tabriz on 6 October, where they were joined by W. Gräf, of Graz, and M. Mehrnusch, of the Geological Survey of Iran.

A mountainous area several miles west of Julfa named Kuh-e-Ali Bashi was visited by the party on 7 October, and it was soon apparent that rocks of Permian age occupied a considerable area in that range. Presence of Triassic rocks was also confirmed. The locality visited was situated an estimated 8 km south of the Aras River and about the same distance west of Julfa. Rain foiled an attempt to return to the same locality on 9 October, and Teichert returned to Teheran on that same day.

Subsequently, suggestions to set up a joint research project with the Geological Survey of Iran in which Teichert and Kummel would concentrate on the Permian-Triassic boundary and Survey-connected geologists would study the general stratigraphy and paleontology of the Permian and Triassic sequences in Kuh-e-Ali Bashi were rejected. Instead, the Geological Survey of Iran developed its own project, sending a small party to Kuh-e-Ali Bashi in the summer of 1967 for the special purpose of studying the Permian-Triassic boundary and the major aspects of the Permian section. This work has been reported on in a paper by Stepanov, Golshani, and Stöcklin (1969).

These authors describe Permian and Triassic sections from Kuh-e-Ali Bashi and from two localities in the Alborz Mountains: from the upper Chalus Valley in the western Alborz Mountains and from a locality 20 km south of Amol in the eastern Alborz Mountains. They also figured, but did not describe, many species of Permian and Triassic fossils from these areas. At Kuh-e-Ali Bashi, the Permian-Triassic section was subdivided as follows (text-fig. 3):

Triassic	*Description*	*Thickness (meters)*
H.	Upper part of Elikah Formation: massive to thick-bedded barren dolomite	200+
G.	Lower part of Elikah Formation: thin-bedded limestone and some shale containing *Claraia*	282.2
F.	*Paratirolites* limestone: nodular, red limestone, cliff-forming, containing *Paratirolites waageni* Stoyanow, *Abichites, Prionolobus, Pseudogastrioceras,* tabulate and rugose corals (*Michelinia, Plerophyllum, Pleramplexus*), and brachiopods (*Orthotetina, Spinomarginifera, Araxathyris, Pseudowellerella*)	3.6
E.	Permian-Eotriassic transition beds: *Bernhardites* Zone, *Dzhulfites* Zone, *Tompophiceras* Zone, containing, in addition to these cephalopods, a fauna of tabulate and rugose corals, brachiopods, and orthocerid cephalopods	12.75
Permian		
	Permian-Eotriassic transition beds: *Phisonites-Comelicania* Zone, containing *Michelinia, Comelicania,* and *Phisonites*	5.1
D.	Upper Julfa beds (*Haydenella-Pseudowellerella* Zone) (unit D), limestone and shale containing rugose corals, brachiopods, *Araxoceras, Vedioceras,* and nautiloids	11.35
C.	Lower Julfa beds (unit C): *Pseudogastrioceras-Permophricodothyris* Zone, *Araxilevis-Orthotetina* Zone, limestone and shale, richly fossiliferous (mostly brachiopods, some nautiloids, and ammonoids)	11.41
B.	Khachik beds (unit B), dark gray, well-bedded limestone, with chert nodules, rich in brachiopods, but also containing algae, foraminifers (including fusulines), rugose and tabulate corals, gastropods, nautiloids, and one trilobite (*Pseudophillipsia*)	168.00

A.	Gnishik beds (unit A), dark gray, thick-bedded limestone, with rare chert nodules, and rich fauna, mainly of brachiopods, but also containing algae, foraminifers, tabulate and rugose corals, gastropods, and one trilobite (*Pseudophillipsia*)	308.00
	Total thickness	1002.41+

Stepanov *et al.* gave the age of the Gnishik and Khachik beds as Guadalupian and the age of the Julfa beds as Dzhulfian. In the latter stage they also included the lowermost unit (*Phisonites-Comelicania* Zone) of their "Permo-Triassic transition beds" without stating specific reasons. In the zonation of the upper part of the "transition beds" by ammonoid genera, Stepanov *et al.* adopted the scheme proposed by Shevyrev (*in* Ruzhentsev and Sarycheva, 1965), but their conclusions were based on extremely limited material, not on critical paleontological studies.

PRESENT INVESTIGATIONS

After Teichert's reconnaissance in October, 1966, Teichert and Kummel visited Kuh-e-Ali Bashi together in the summer of 1968, spending two weeks on field studies in the general area visited by the Iranian party in the previous year. They discovered that the information published by Stepanov *et al.* (1969) had been obtained essentially from a single section, measured by F. Golshani and B. Hamzepour.

In the place chosen by these investigators, the "transition beds" are poorly exposed and very difficult of access. Thus, Kummel and Teichert extended their investigations along the strike of the beds in a small valley where this unit is exposed for a distance of about 1 kilometer. Here, efforts were concentrated on four localities (Text–figs. 5–10). In two of these, outcrops were too poor to allow detailed measurement of the sections, but fossils were collected from carefully determined intervals within stratigraphic distances of about 2 meters. Thus, while contamination from higher beds naturally occurred, stratigraphically highest occurrences of most species could be determined. In the remaining two localities outcrops were sufficiently continuous to allow measurements of the sections and, accordingly, exact determination of the stratigraphic position of many fossils, although, here too, fossils were also collected from "float."

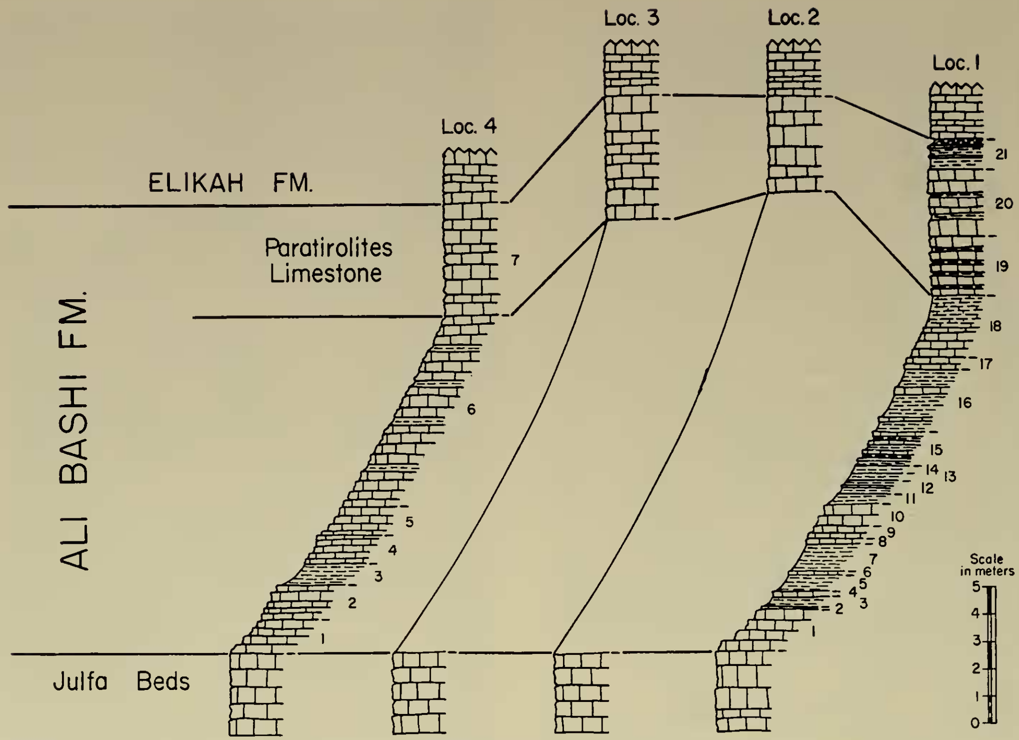
Subsequent examination of their large fossil collections has led Teichert and Kummel to conclude that the "Permian-Eotriassic transition beds" of Stepanov *et al.* (1969) were in fact of latest Permian age and that, indeed, the Permian-Triassic boundary should be placed at the top of the *Paratirolites* beds. Detailed documentation for these conclusions is presented in this paper. A preliminary account of their views was presented at the International Permian-Triassic Conference at Calgary, Alberta, 23–26 August 1971, an abstract of which was published in the Bulletin of Canadian Petroleum Geology (Kummel and Teichert, 1971: 336–337). The full paper was presented by Kummel at the Calgary meeting on 23 August 1971, and the manuscript was immediately transmitted for publication in the Proceedings of that meeting (Alan Logan and L. V. Hills, editors).

Teichert was able to return to Kuh-e-Ali Bashi for a brief visit in June, 1970, mainly for the purpose of taking new photographs of their localities.

It is interesting to record publication of a paper by Waterhouse in May, 1972, in which he expressed views that are identical to Kummel and Teichert's. To the best of their knowledge, Waterhouse never visited Kuh-e-Ali Bashi nor has he ever studied fossils from this area. He did, however, attend the Permian-Triassic Conference at Calgary in August, 1971, and the manuscript of his paper was submitted on 27 September 1971.

STRATIGRAPHY OF THE ALI BASHI FORMATION

We propose the name Ali Bashi Formation for the lithologic unit that lies between the top of the Julfa beds and the base of the thin-bedded medium gray limestone, con-



Text-figure 5. Stratigraphic sections of latest Permian and early Triassic formations at Kuh-e-Ali Bashi, northwest Iran.

taining *Claraia,* that can be correlated with the Elikah Formation of the Alborz Mountains. The Ali Bashi Formation includes beds 52–61 of the stratigraphic section published by Stepanov *et al.* (1969: 35–36, 40), and is equivalent to the "Permian-Triassic transition beds," including the *Phisonites* Zone, as well as the *Paratirolites* limestone (unit F) as described in that publication.

Lithology. The bulk of the Ali Bashi Formation consists of alternating impure aphanitic limestone and shale. Its top part is made up of grayish red limestone containing *Paratirolites.* This limestone forms such a distinct lithologic unit that it may well be distinguished formally as a member of the Ali Bashi Formation although we have refrained from doing so. For details of the lithology of the Ali Bashi Formation, the reader is referred to the description of the stratigraphic sections, especially at Localities 1 and 4.

Thickness. According to our measurements, the thickness of the formation varies from 16.5 m at Locality 4 to 20.5 m at Localities 2 and 3. These figures are in agreement with the total thickness given by Stepanov *et al.* for their beds 52–61, which was 21.6 m. The locality where Golshani and Hamzepour (*in* Stepanov et al., 1969) measured their section lies about 300 m to the north of our Locality 4. At our Locality 1, which lies about 200 m south of our Locality 2, the thickness of the formation is 18.8 m.

The thickness of the uppermost part of the formation, herein referred to as *Paratirolites* limestone, is 5.8 m at Locality 1, 3.5 m at Locality 2, 4.5 m at Locality 3, and 4.2 m at Locality 4. At the locality described in Stepanov *et al.* (1969) it is 3.6 m.

Type locality. In the absence of good

maps, the exact location of the type locality of the Ali Bashi Formation is somewhat difficult to describe. It is indicated in Figure 2 of this paper only in a very general way as lying about 10 km due west of the town of Julfa. It is reached by driving about 7 km along a gravel road leading southwest from Julfa in the direction of Khoy, then leaving the road and turning northwest to drive for about 6 km over a uniformly rising pediment surface in the direction of the only large valley visible at this point from the road. One can reach by jeep the foot of the mountains on the western side of this valley. From here, it is necessary to proceed up the valley on foot for another 2 km until the first outcrops of dark-colored Khachik Limestone are reached. At this point, one turns northeast, crosses a low ridge consisting of Julfa beds, and descends into a much smaller and narrower valley on the northeastern side. Turning north in this small valley, the outcrops of the Ali Bashi Formation studied by us may be followed and are easily accessible for about 1 km on the eastern side. They probably extend for some distance farther north, where, however, they are almost inaccessible.

The outcrops in the lower part of the valley, as described above, are here designated as the type locality of the Ali Bashi formation (Text–figs. 6–10). In this belt, four stratigraphic sections were selected for detailed study, but in only two were the rocks sufficiently well exposed to warrant detailed measuring. Because time did not permit us to make our own reconnaissance

Text-figure 6. View of strike valley at Kuh-e-Ali Bashi. Locality 3 is the prominent nose of the escarpment behind the individuals in the picture. The Julfa beds include the strata from the left of the picture to the top of the hard bed in the middle of the slope. The Ali Bashi Formation extends from there to the base of the prominent scarp, which is made of the Elikah Formation (Kummel photograph).

Text-figure 7. Locality 4 is in the mid-part of the right hand side of this photograph. The massive limestone beds at the top of the slope are the Elikah Formation. These are underlain by the Ali Bashi Formation. The top of the underlying Julfa beds is the prominent hard bed at the mid-part of the slope (Kummel photograph).

map, the exact positions of the sections cannot be pinpointed. However, this is not judged to be a serious shortcoming because the studied outcrops extend across merely a few hundred meters.

A description of the sections that we term Localities follows. Locality 1 is the southernmost (Text–fig. 9), Locality 4 the northernmost (Text–fig. 7); the distance between them is about 500 m. Localities 2 and 3 (Text–figs. 6, 8) are close together, about halfway between 1 and 4. The section measured by Golshani and Hamzepour (*in* Stepanov *et al.*, 1969) lies about 300 m to the north of our Locality 4.

Age and correlation. It is the purpose of this paper to document more thoroughly that the Ali Bashi Formation in its entirety is of latest Permian age and that no part of it can be assigned to the Triassic. This conclusion has already been presented in two previous publications (Kummel and Teichert, 1971, 1973). The conclusion reached by Stepanov *et al.* (1969) that these beds, with the exception of the lowest 5 meters, are of Triassic age is not supported by a reevaluation of the paleontological evidence provided by the study of our fossil collections.

North of the Aras River, in Armenian Dzhulfa, the correlative strata are bed 5 of the Dzhulfian Stage and beds 1–4 of the Lower Triassic ("Induan") of Arakelyan, Grunt, and Shevyrev (*in* Ruzhentsev and Sarycheva, 1965). Taraz (1971a, b) adopted the same correlation for what he regarded as equivalent beds in a Permian-Triassic section of the Abadeh region in central Iran.

Text-figure 8. The Ali Bashi Formation at Locality 2. The formation includes the strata between the small hard ledge near the base of the picture and the more prominent ledge toward the top of the picture (Kummel photograph).

Description of Stratigraphic Sections at Type Locality of Ali Bashi Formation, Kuh-e-Ali Bashi

(Distribution of Conodonts is summarized in Table 7)

Locality 1

Bed	*Description*	*Thickness (meters)*
	Elikah Formation	
22	Limestone, medium gray, thin-bedded to platy, in part aphanitic, hard, containing *Claraia* (Conodont samples 22L, 22M, 22U).	
	Ali Bashi Formation	
21	Shale, in alternating yellowish gray and light olive gray beds, each about 20 cm thick; also olive gray limestone beds; poorly exposed; seemingly unfossiliferous (Conodont sample 21).	1.1
20	Limestone, aphanitic, grayish red, nodular, with some shaly interbeds; contains *Paratirolites* and, microscopically, several types of nonfusulinid foraminifers, shell fragments, large numbers of ostracod shells, and some echinoderm remains (Conodont samples 20L, 20M, 20U).	2.5
19	Limestone, aphanitic, grayish red, in beds 5–15 cm thick, separated by shaly beds, 2–3 cm thick; partly nodular; some beds bioturbated; contains *Paratirolites kittli, P. mojsisovicsi* and, microscopically, at least 2 types of nonfusulinid foraminifers, very numerous ostracod shells, both articulated and disarticulated, and some echinoderm remains; a thin basal bed contains an abundance of bairdiid ostracods associated with *Hollinella* sp. (Conodont samples 19L, 19U).	2.2
18	Limestone, grayish red, in part very argillaceous, grading upward into calcareous shale, thin-bedded, bioturbated; in thin section nu-	

Text-figure 9. Locality 1, the upper part of the Ali Bashi Formation overlain by the lower part of the Elikah Formation. The *Paratirolites* limestone is the lower scarp separated by a bench from the overlying, more conspicuous scarp (Kummel photograph).

merous ostracod shells, both articulated and disarticulated, and some echinoderm fragments (Conodont samples 18L, 18U). 2.3

17 Limestone, aphanitic, pale red, hard, ledge-forming, nodular in part; in thin section few ostracod shells, both articulated and disarticulated. Contains *Shevyrevites shevyrevi* (Conodont sample 17). 0.4

16 Shale, light to medium gray, with several beds of aphanitic argillaceous limestone beds, 2–8 cm thick, forming thin resistant ledges; most limestone beds bioturbated, containing greater or lesser amounts of ostracod shells, both articulated and disarticulated, some echinoderm remains, and, possibly, nonfusulinid foraminifers, also *Iranites transcaucasius* (in place) (Conodont samples 16L, 16M, 16U). 2.3

15 Limestone, aphanitic, argillaceous, light olive gray, in beds 2–8 cm thick, alternating with layers of dark gray shale; limestone in thin section contains scattered ostracod shells, most of them disarticulated, and few echinoderm remains; some limestone beds weakly bioturbated, showing remnants of original lamination (Conodont samples 15M, 15U). 1.25

14 Siltstone, yellowish gray, no megafossils (Conodont sample 14). 0.3

13 Shale, very dark red, poorly exposed. 0.3

12 Shale, very dark red, with some thin, hard, light olive gray, aphanitic limestone beds; these contain, microscopically, some scattered, mostly disarticulated ostracod shells (Conodont sample 12). 0.5

11 Shale, very dark red, poorly exposed. 0.4

10 Limestone, aphanitic, argillaceous, pale brown to light brown-

Text-figure 10. The Triassic Elikah Formation at Kuh-e-Ali Bashi (Kummel photograph).

	ish gray; contains *Iranites transcaucasius* (in place), *Paratirolites spinosus* (in place), *Pleuronautilus* sp. indet. and, microscopically, abundant, mostly disarticulated, ostracod shells (Conodont samples 10M, 10U).	0.8
9	Limestone, aphanitic, argillaceous, light olive gray; bioturbated, in beds 2.5–5 cm thick, with interbeds of dark shale; contains disarticulated and articulated ostracod shells (Conodont sample 9).	0.45
8	Limestone, aphanitic, argillaceous, grayish orange pink; ledge-forming; bioturbated; contains few disarticulated and articulated ostracod shells (Conodont sample 8).	0.2
7	Shale, pale brown; *Strigogoniatites* sp. indet. was found at this level (Conodont sample 7).	1.0
6	Limestone, aphanitic, argillaceous, light olive gray; weakly bioturbated; seemingly unfossiliferous.	0.1
5	Shale, pale brown, poorly exposed (Conodont sample 5).	0.6
4	Limestone, aphanitic, argillaceous, pale brown; strongly bioturbated; few ostracod shells, both articulated and disarticulated (Conodont sample 4).	0.2
3	Shale, very dark red, poorly exposed.	0.4
2	Limestone, aphanitic, argillaceous, light brownish gray; strongly bioturbated; just one hard bed; scattered ostracod shells, both articulated and disarticulated (Conodont sample 2).	0.1
1	Limestone aphanitic, very argillaceous, light olive gray, thin-bedded; strongly bioturbated; contains *Michelinia vesiculosa*, *Liroceras* sp. indet. (Conodont sample 1).	1.4

JULFA BEDS

Limestone, aphanitic, argillaceous, light brownish gray; slightly bioturbated; abundant ostracod shells, mostly disarticulated; taken 1 m below base of

Ali Bashi Formation (Conodont sample 0).

Total thickness of Ali Bashi Formation 18.8

Locality 2

Quality of outcrops insufficient for detailed stratigraphic section. Thickness of Ali Bashi Formation to base of *Paratirolites* beds is 17 m.

Paratirolites beds, only part of formation well exposed, are 3.5 m thick; they are aphanitic, argillaceous limestone, pale red, strongly bioturbated; containing, in addition to *Paratirolites,* much organic debris: gastropod and cephalopod fragments, articulated and disarticulated ostracod shells, echinoderm fragments, including crinoid columnals; in one thin section a transverse section of a keeled cephalopod shell 3 mm in diameter, possibly representing the early ontogenetic stage of a xenodiscid of the type of *Xenodiscites.*

Ufimia sp. was found at 4.5 m and 13.5 m above the base of the Ali Bashi Formation; *Pleramplexus leptoconicus* at 0.7, 1.0 and 13.5 m; *Iranites transcaucasius* was found at 0.7, 2.1, 2.2, 3, 3.5, 4.5, 7.5, 9, and 10.5 m above base of formation; *"Pseudotirolites"* sp. indet. at 2.1 m above base of formation; *Pseudogastrioceras abichianum* at 0.9 and 4.5 m above base of formation; *Shevyrevites shevyrevi* at 7.5, 9, and 10.5 m above base of formation; *Paratirolites kittli* in place in *Paratirolites* beds, *Paratirolites spinosus* at 13.5 m above base of formation, *Paratirolites mojsisovicsi at* 9 m above base of formation; *Strigogoniatites* sp. indet. at 2.1 m above base of formation; *Tainoceras* sp. indet. at 4.5 m above base of formation. Distribution of conodonts is summarized in Table 7.

Locality 3

Quality of outcrop insufficient for detailed stratigraphic section. Thickness of Ali Bashi Formation to base of *Paratirolites* beds is 16 m. The *Paratirolites* beds, the only part of formation exposed, are 4.5 m thick and are similar in lithology and fossil content to those at Locality 2.

Pleramplexus leptoconicus was found at 4.5 m and 7. 5 m above the base of the Ali Bashi Formation; *Iranites transcaucasius* at 4.5, 6, and 7.5 m above base of formation; *Pseudogastrioceras abichianum* at 4.5 and 7.5 m above base of formation; *Shevyrevites shevyrevi* at 7.5 m above base of formation; *Xenodiscus dorashamensis* at 1.5 m above base of formation; *Phisonites triangulus* at 1.5 m above base of formation; *Paratirolites kittli* from *Paratirolites* beds, also at 11 m above base of formation; *P. mojsisovicsi* at 3 m above base of formation; *Strigogoniatites* sp. indet. at 4.5 m above base of formation; *Temnocheilus* sp. indet. at 3 m above base of formation; ?*Neocycloceras* sp. indet. at 4.5 m above base of formation; *Araxathyris araxensis minor* and *Araxathyris* sp. at 4.5 m above base of formation.

Locality 4

(Distribution of Conodonts is summarized in Table 7)

Bed	*Description*	*Thickness (meters)*
	Ali Bashi Formation	
7	Limestone, aphanitic, argillaceous, pale red; cliff-forming; contains brachiopods at 1 m (*Araxathyris araxensis minor*), *Paranautilus* sp. indet. at 2.3 m, *Paratirolites* sp., and, microscopically, abundant articulated and disarticulated ostracod shells, scattered echinoderm fragments (Conodont samples 7L, 7M, 7U).	4.2
6	Limestone, aphanitic, argillaceous, grayish red, nodular; slope-forming; strongly bioturbated; few interbeds of reddish shale; contains abundant debris of ostracod shells, but few articulated specimens (Conodont sample 6).	7.0
5	Limestone, aphanitic, argillaceous, pale red, nodular, hard; weakly bioturbated; contains *Paratirolites kittli, Pleuronautilus* sp. indet., *Pleramplexus leptoconicus,* and, microscopically, scattered, mostly fragmented, ostracod shells (Conodont sample 5).	0.4–1.0
4	Limestone, red, nodular, crinoidal in upper part.	1.1
3	Shale, "reddish," contains *Plerophyllum dzhulfense, Araxathyris araxensis minor, Lopingoceras* sp.,	

	Domatoceras sp. indet., *Urartoceras* sp. indet., and crinoid stems.	0.75
2	Limestone, aphanitic, argillaceous, pale red, nodular, thin-bedded, ledge-forming; bioturbated; contains few disarticulated ostracod shells, some echinoderm fragments, including crinoid columnals, *Phestia* sp. indet., *Araxathyris araxensis minor* (Conodont sample 2).	1.3
1	Limestone, aphanatic, argillaceous, pale red, thin-bedded; slope-forming; bioturbated; contains some debris of ostracod shells and few echinoderm fragments, including crinoid columns (Conodont sample 1).	1.2
	Total thickness of Ali Bashi Formation about	16.5

FAUNA OF ALI BASHI FORMATION

Our collections from the Ali Bashi Formation have yielded specimens referable to approximately 40 genera of fossil invertebrates; however, only a few of these can be identified as to species. The collections include corals, bryozoans, brachiopods, bivalves, nautiloids, ammonoids, ostracods, crinoid stems, and conodonts. Mega-invertebrate fossils are by no means abundant, but the dominant element by far is the ammonoids. Nautiloids are second in abundance, while all other groups are sparsely represented in our collections, some by only a single specimen. Among the microfossils conodonts are very abundant, as are ostracods in certain beds.

Anthozoa

In our collections from the Ali Bashi Formation at Kuh-e-Ali Bashi, *Pleramplexus* is by far the most abundantly represented genus. This is in contrast to the relative proportions of genera reported from the north side of the Aras River.

Below we discuss the following species that we have identified from the Ali Bashi Formation:

Michelinia vesiculosa Chudinova
Plerophyllum dzhulfense Ilina
Ufimia sp.
Pleramplexus leptoconicus (Abich)

All four species are also represented in our collections from the Julfa beds, immediately below the Ali Bashi Formation, where we collected them close to our Locality 4.

From the "Induan Stage" of Soviet Dzhulfa (Dorasham 1 and 2), Ilina (1962) and Chudinova (*in* Ruzhentsev and Sarycheva, 1965) listed or described the following species of corals:

Khmeria pumila Chudinova
Plerophyllum armenicum Ilina
P. cuneatum Ilina
P. differentiatum Ilina
P. dzhulfense Ilina
Pleramplexus leptoconicus (Abich)
P. minimus Ilina

Plerophyllum differentiatum is the species most abundantly represented in the collections available to Ilina and Chudinova. *Khmeria pumila, Plerophyllum dzhulfense* and *Pleramplexus leptoconicus* are the only species surviving from the preceding Dzhulfian Stage, whereas the other four species first appear in the "Induan."

Stepanov *et al.* (1969) mentioned *Michelinia* sp., *Pleramplexus minimum* [*sic*] Ilina, and *Plerophyllum* sp. from their "Transition beds" at Kuh-e-Ali Bashi.

Bryozoa

Our collections from the Ali Bashi Formation contain a fragment of an annulated orthocone completely encrusted by a trepostomatous bryozoan. R. S. Boardman studied the specimen and informed us (written communication to Teichert, 28 May 1971) that it is generically unidentifiable but probably belongs to the family Stenoporidae.

Morozova (*in* Ruzhentsev and Sarycheva, 1965) recorded only one species of Bryozoa from the "Induan" of Soviet Dzhulfa. This is *Polypora dorashamensis* Nikiforova, a cryptostomate. This species also occurs in the underlying Dzhulfian beds where it is represented by 50 specimens in the Soviet collections. Morozova listed only two specimens from the "Induan." The species is also represented in the Upper Permian Chandalaysk Group of the Vladivostok region.

Brachiopoda

Brachiopods are relatively rare in the Ali Bashi Formation at Kuh-e-Ali Bashi; our collections contain only ten specimens. From this small sample G.A. Cooper (written communication, 13 February 1970) identified *Araxathyris araxensis minor* Grunt and *Araxathyris* sp. indet. It is of interest to note that from Soviet Dzhulfa Sarycheva, Sokolskaya, and Grunt (*in* Ruzhentsev and Sarycheva, 1965) recorded 454 specimens from the "Induan", but 389 of these are assigned to one species, *A. araxensis minor* Grunt, the same species that makes up the bulk of the specimens from the Ali Bashi Formation. All the remaining species recognized from the "Induan" of Soviet Dzhulfa are represented by few specimens, and some by only one.

Sarycheva, Sokolskaya, and Grunt (*in* Ruzhentsev and Sarycheva, 1965) described or listed the following species of brachiopods from the "Induan Stage" of Soviet Dzhulfa:

Spinomarginifera pygmaea Sarycheva
Haydenella kiangsiensis (Kayser)
H. minuta Sarycheva
Araxathyris araxensis minor Grunt
A. ogbinensis Grunt
Orthotichia parva Sokolov
Enteletes dzhagrensis Sokolov
Orthotetina sp.
Terebratuloidea sp.

These authors commented on this assemblage as follows (translation of Ruzhentsev and Sarycheva, 1965, by D.A. Brown, 1968: 75): "The lower Triassic Induan assemblage is strongly impoverished in numbers and in systematic relationships as compared with the brachiopod assemblage of the upper beds of the Dzhulfian Stage. Of the 9 species occurring here, 5 pass up from the Permian; unknown in the underlying deposits are *Enteletes dzhagrensis, Orthotichia parva, Orthotetina* sp. and *Terebratuloidea* sp. Let us note that the first three genera appeared even in the Middle Carboniferous and the last genus, in the Early Permian; they all died out at the boundary with the Triassic, if we ignore the present region of Trans-Caucasia."

Bivalves

Our collections from the Ali Bashi Formation at Kuh-e-Ali Bashi contain one small specimen of *Phestia* sp. indet. identified for us by N.D. Newell (written communication to Kummel, 16 December 1969). The monograph on the Permian and Triassic strata of Soviet Dzhulfa edited by Ruzhentsev and Sarycheva (1965) contains no data on bivalves.

Nautiloidea

Our collections from the Ali Bashi Formation at Kuh-e-Ali Bashi yielded the following nautiloids:

?*Dolorthoceras* sp.
Neocycloceras sp.
Lopingoceras sp.
Tainoceras sp. indet.
Metacoceras sp. indet.
Pleuronautilus sp. indet.
Temnocheilus sp. indet.
Domatoceras sp. indet.
Liroceras sp. indet.
Paranautilus sp. indet.

Shimanskiy (*in* Ruzhentsev and Sarycheva, 1965) recognized the following nautiloids from the Ali Bashi Formation of Soviet Dzhulfa:

?*Neocycloceras* sp.
Tainoceras sp. 1 (ex. gr. *changlingpuense* Chao)
T. sp. 2 (ex. gr. *changlingpuense* Chao)
T. sp. 3
Metacoceras sp. 2 (ex. gr. *dorsoarmatum* Abich)
?*Foordiceras* sp. 2
Pleuronautilus ex. gr. *dieneri* Krafft
?*P.* sp.
Tainionautilus sp.
Domatoceras sp. 2
?*Paranautilus* sp.
Syringonautilus vagus Shimanskiy

Most of the genera in these two faunas are characteristic forms of the late Paleozoic, namely Late Carboniferous and Permian. Only *Syringonautilus* has previously been recorded from the Middle and Upper Triassic. However, this identification is doubtful. Kummel (1953) has demonstrated that there was no significant change in the composition of nautiloid faunas across the Permian-Triassic boundary. He (Kummel, 1953: 1) summarized this relationship as follows: "Evolution of the nautiloids in the Triassic is mostly one of culminating patterns and modes started in the late Paleozoic." The nautiloids thus can make no significant contribution to the determination of the Permian-Triassic boundary.

Straight "nautiloids" (orthocerids) are reasonably common and are represented by the genera *?Dolorthoceras, Neocycloceras,* and *Lopingoceras*. Some representatives of the last-named genus are very similar, and possibly identical, to the type species, *Lopingoceras lopingense* (Stoyanow), which was first reported from the Upper Permian of Soviet Dzhulfa. This genus was not reported by Shimanskiy (*in* Ruzhentsev and Sarycheva, 1965) from the equivalents of the Ali Bashi Formation in Soviet Dzhulfa, but *Neocycloceras* occurs there, both in the Dzhulfian beds and in the overlying lower "Induan."

Ammonoidea

Our collections of ammonoids from the Ali Bashi Formation near Iranian Julfa contain specimens of the following 15 species in 13 genera:

Pseudogastrioceras abichianum (von Möller)
Strigogoniatites sp. indet.
?Propopanoceras sp. indet.
Neoaganides n. sp.
"Pleuronodoceras" sp. indet.
"Pseudotirolites" sp. indet.
"Pseudostephanites" sp. indet.
Phisonites triangulus Shevyrev
Xenodiscus dorashamensis Shevyrev
Iranites transcaucasius (Shevyrev)
Shevyrevites shevyrevi Teichert and Kummel, n. g., n. sp.
Urartoceras sp. indet.
Paratirolites kittli Stoyanow
P. mojsisovicsi Stoyanow
P. spinosus (Shevyrev)

Ruzhentsev and Sarycheva (1965) listed the following 17 species and 9 genera from the Ali Bashi Formation of Soviet Dzhulfa:

Pseudogastrioceras abichianum (Moeller)
Stacheoceras tschernyschewi (Stoyanow)
Phisonites triangulus Shevyrev
Xenodiscus dorashamensis Shevyrev
Tompophiceras transcaucasium Shevyrev
Bernhardites radiosus (Frech)
B. nodosus Shevyrev
Dzhulfites spinosus Shevyrev
D. nodosus Shevyrev
Paratirolites kittli Stoyanow
P. waageni (Stoyanow)
P. vediensis Shevyrev
P. trapezoidalis Shevyrev
P. dieneri Stoyanow
Abichites stoyanowi (Kiparisova)
A. mojsisovicsi (Stoyanow)
A. abichi Shevyrev

These ammonoids range stratigraphically through five beds (or zones) as follows (from top to bottom):

Beds with *Paratirolites*
Beds with *Bernhardites*
Beds with *Dzhulfites*
Beds with *Tompophiceras*
Beds with *Phisonites*

The complete sequence of these ammonoid beds is present apparently only at locality Dorasham 2 in Dzhulfa Gorge. In the remaining regions of Transcaucasia the beds with *Phisonites* and those with *Tompophiceras* are apparently absent. The beds with *Paratirolites* are widely distributed in Transcaucasia and are present in all sections studied by the Soviet geologists. The beds with *Dzhulfites* and *Bernhardites* are more restricted in their distribution and are quite thin in most sections other than that of Dorasham 2. According to our systematic revisions of the taxa in the Ali Bashi Formation, these Soviet faunas consist of nine species belonging to seven genera.

The most significant aspect of our ammonoid fauna is the number of additional genera over that of previous reports on the ammonoids from this formation. The additional genera are *Strigogoniatites, Neoaganides, "Pleuronodoceras," "Pseudotirolites," "Pseudostephanites,"* and *Urartoceras*. Of these, *"Pleuronodoceras," "Pseudotirolites,"* and *"Pseudostephanites"* are of particular interest as they were first illustrated, but not described, by Chao (1965) from the highest Permian strata in China which were selected as the type of the Changhsingian Stage by Furnish and Glenister (1970). These three genera are known only from northwestern Iran and China.

Strigogoniatites is a relatively rare goniatite that ranges through much of Permian time. To date only six species have been assigned to this genus and these are based on very few specimens. In its morphological features the genus is gradational with *Pseudogastrioceras*. On the basis of the available data, angularity of the venter develops at progressively younger stages through Permian time. One of our specimens has an acute venter at a diameter of 18 mm. This is the smallest diameter for the appearance of this feature noted so far, suggesting that this is the youngest representative of this genus so far recorded.

The lowest beds of the Ali Bashi Formation contain specimens of *Phisonites triangulus* Shevyrev and *Xenodiscus dorashamensis* Shevyrev. These species were first described from the same stratigraphic position in Soviet Dzhulfa. *Phisonites* is a monotypic genus known only from the Dzhulfa region. *Xenodiscus* is a fairly common ammonoid of Upper Permian deposits wherever they occur. It is a very generalized form, considered to be ancestral to the Early Triassic ophiceratids and glyptophiceratids. Schindewolf (1954) was the first to distinguish clearly the morphological features that distinguish *Ophiceras* from *Xenodiscus*. The former has three umbilical lobes and the latter only two. Schindewolf (1954: 176) also discussed the possibility that the forms from the Lower Triassic *Ophiceras* beds of East Greenland placed by Spath (1935) in *Ophiceras* (*Metophiceras*) are perhaps more properly placed in *Xenodiscus*. He based his argument primarily on the suture of *Ophiceras* (*Metophiceras*) *subdemissum* (Spath, 1935, pl. 13, fig. 3). We find it difficult to accept this conclusion because the data are far too meager. The earliest Triassic ophiceratids are an extremely plastic stock that reflects a wide adaptive radiation. One expression of this radiation is the wide variation in shape of whorl section and degree of involution. The suture likewise shows extensive variation. *Ophiceras* (*Metophiceras*) is better understood as part of the ophiceratid radiation than as a surviving *Xenodiscus*. The record available suggests that *Xenodiscus* showed little significant evolutionary change throughout the Late Permian, but that it was one of its offspring, the ophiceratids, that underwent extensive radiation.

The best known goniatite from the Julfa region is *Pseudogastrioceras abichianum* (von Möller). In Soviet Dzhulfa, Shevyrev (*in* Ruzhentsev and Sarycheva, 1965) recorded only a single specimen from his *Bernhardites* Zone. Specimens of this species are quite common in the underlying *Phisonites* Zone, and predominant in the *Araxoceras* Zone. Our collections contain 12 specimens from the Ali Bashi Formation, the stratigraphically highest of which comes from a horizon 7.5 m above the base of the unit. This genus is widely distributed in Permian strata throughout the world. Stepanov *et al.* (1969: 40) record *Pseudogastrioceras* sp. from the *Paratirolites* beds.

The specimen we assign to ?*Propopanoceras* is quite similar in overall appearance to *P. kweichowense* Chao (1965) from the Lower Permian of south China. However, the poor preservation of the specimen from the Ali Bashi Formation does not permit more than a suggested relationship. The only other species of *Propopanoceras* are from Lower Permian (Sakmarian) strata of the Urals and Western Australia.

Another interesting new taxon recorded here from the Ali Bashi Formation is *Neoaganides* n. sp. Our collections from the underlying Dzhulfian beds contain a specimen now being studied by W.M. Furnish and B. F. Glenister (written communication to Kummel, 15 December 1969) which they think is conspecific with the specimen from the Ali Bashi Formation. It is quite apparent that this is a very long-ranging genus, of little value for age determination.

Araxoceratids are a very characteristic element of the Dzhulfian strata both in the region of Soviet Dzhulfa and at Kuh-e-Ali Bashi in Iran. The specimen we assigned to *Urartoceras* sp. indet. is from float, 3 meters above the base of the Ali Bashi Formation, well within the *Phisonites* Zone. The genus was known previously only from the underlying *Vedioceras* Zone in Soviet Dzhulfa.

One of the most common ammonoids in the Ali Bashi Formation is the one assigned by Shevyrev (*in* Ruzhentsev and Sarycheva, 1965) to *Tompophiceras transcaucasium*. Shevyrev had only eight specimens, all from Dorasham 2, in Soviet Dzhulfa, a striking difference from its predominance in our collections from Kuh-e-Ali Bashi. Our material adds appreciably to knowledge of this species, which is discussed in detail in the systematic chapter. The primary conclusion is that *T. transcaucasium* is not congeneric with *T. fastigatum*, the type species of *Tompophiceras*. Popov (1961) clearly pointed out that fastigation of the venter of his type, and only, specimen, was confined to the outer volution, and that the inner volutions have broadly rounded venters. Tozer's (1969) contention that acuteness of the venter in *Tompophiceras fastigatum* is due to crushing is rejected by Popov (personal communication). Kummel was able to examine the type specimen in June 1970, and agrees completely with Popov's conclusions. Acuteness of the venter in the species from the Ali Bashi Formation is attained at a much earlier growth stage. The smallest specimen in our collection has an acute venter at a shell diameter of 13 mm.

The evolute, ribbed ammonoids of the Ali Bashi Formation, which Shevyrev assigned to his new genus *Bernhardites*, are extremely difficult to interpret. In the systematic chapter we explain in detail that the Ali Bashi species are not congeneric with *Celtites radiosus* Koken, the type species of *Bernhardites*, from the Lower Triassic of the Salt Range, West Pakistan. It is likewise pointed out that *Celtites radiosus* is not represented in the Lower Ceratite limestone as stated by Noetling (*in* Frech, 1905: 164), but rather occurs in the overlying Ceratite marls. Ammonoids of the general morphology of *Bernhardites* are fairly common in Upper Permian and Lower Triassic strata. The great difficulty in identification makes precise time correlations tenuous at best. For these reasons a new generic name, *Shevyrevites*, is introduced for the species represented in the Ali Bashi Formation.

The most characteristic ammonoids of the Ali Bashi Formation are assignable to species of *Paratirolites*. For this group of ammonoids Shevyrev (*in* Ruzhentsev and Sarycheva, 1965) recognized three genera (*Paratirolites* Stoyanow, *Dzhulfites* Shevyrev, and *Abichites* Shevyrev), containing ten species altogether. Paratirolitids are by far the most common and abundant ammonoids in our collections. Study of these specimens leads us to conclude that this group consist of only one genus and three species. The uniqueness of the paratirolitids rests in the suture. For a long time it was thought that they represented an endemic group confined to the Ali Bashi Formation. Now, however, they are known from correlative strata near Abadeh, central Iran (Taraz, 1969), and from an unknown horizon and locality in northern Madagascar (Tozer, 1969). In the Abadeh region the paratirolitids occur in a 19-meter bed of brownish red limestone that is reported also to contain *Pseudogastrioceras* and *Bernhardites*. Earlier interpretations of *Paratirolites* suggested affinities with *Stephanites* of the Upper Ceratite limestone in the Salt Range of West Pakistan, emphasizing the nodose ornamentation and deemphasizing differences in the suture. Examination of our large collection of *Paratirolites* clearly shows that its suture is very distinctive and its ornament much more variable than in the Salt Range species of *Stephanites*.

Ostracoda

It is apparent from thin-section studies on rock specimens from the Ali Bashi Formation at Kuh-e-Ali Bashi and from examination of residues prepared for conodont studies that ostracods are quite abundant at several levels (Plate 14). From one sample, a red mudstone bed immediately at the base of the *Paratirolites* beds, I.G. Sohn (written communication to Teichert, 21 December 1971) was able to identify:

Hollinella sp. cf. *H.? tuberculata* Belousova
Bairdia spp.
Bairdiacea gen. indet.

Sohn concluded that the sample was of Permian age on the basis of the presence of *Hollinella*.

Belousova (*in* Ruzhentsev and Sarycheva, 1965) recorded 19 species from the "Induan" of Soviet Dzhulfa. These species are:

Healdia incognita Belousova
Healdianella dorashamensis Belousova
H. splendida Belousova
Fabilicypris subgeinitziana Belousova
F. obuncus Belousova
F. geinitziana
F. hoxabarensis
Hollinella sp. aff. *H. cushmani*
Bairdia armenica Belousova
B. beedei
B. sp. aff. *B. hassi*
B. rhomboidalis
B. anbeedei Belousova
B. intermedia Belousova
B.? subglenensis Belousova
B. pseudoobuncus Belousova
B. subhassi Belousova
Orthobairdia sp. aff. *O. guadalupiana* Hamilton
Acratinella obscura Belousova

The essentially Paleozoic affinities of this fauna are evident.

Crinoidea

Crinoids are present in moderate abundance, represented by stem fragments only, among which several types of columnals can be distinguished. One of these is similar, or possibly identical, to the columns of *Erisocrinus araxensis* Yakovlev, described from uppermost Permian beds of Soviet Dzhulfa. Strangely enough, all our crinoid material was collected from beds 2 and 3 in Locality 4, although we spent less time in sampling this section than each of the other three.

No crinoids are mentioned from any part of the Permian or "Induan" in Ruzhentsev and Sarycheva's (1965) report.

Conodonts

Bulk samples from Permian-Triassic rocks at Kuh-e-Ali Bashi were processed for conodonts. General information about the number, size, weight, productivity, and stratigraphic distribution of the samples is summarized in Table 1, and information about the frequency and distribution of the conodont species represented is given in Table 7 (see p. 425).

As indicated in Table 1, 35 of the 48 samples are from the Ali Bashi Formation (units 52 through 61 of Stepanov *et al.*, 1969); one is from a level 1.0 m below the Ali Bashi Formation (in unit 51 of Stepanov *et al.*, 1969); and 12 are from the lower 38 m of the Elikah Formation. In addition to these samples, we have another (OSU*

* Ohio State University.

Table 1. Sample Data

Section: Teichert & Kummel	Section: OSU	Number of Samples	Stratigraphic Position: Below Ali Bashi	Stratigraphic Position: Ali Bashi	Stratigraphic Position: Above Ali Bashi	Average Sample Weight (g)	Avg. No. Conodonts per kg	Total Conodonts Recovered
Loc. 1	69SA	38	1(0)*	25(1)	12(3)	0-20U: 1766	113	4722
						21-C8: 718	10.5	
Loc. 2	69SB	3	0	3(0)	0	1106	100	273
Loc. 3	69SC	7	0	7(0)	0	1593	109	1180
Bed 67	67GH	1	0	0	1	?	?	42

* Numbers in parentheses indicate number of samples that did not produce conodonts.

laboratory number 67GH-28) from unit 67 of the Elikah Formation. This sample represents matrix from the Elikah ammonoid identified as *Meekoceras* sp. by Stepanov *et al.* (1969: 41) and preliminary comments on conodonts recovered from it have already been published (*in* Stepanov *et al.*, 1969: 64).

As indicated in Table 1, 44 of the 48 samples were productive and yielded a total of 6,112 discrete conodont elements. An additional 42 specimens were derived from sample 67GH-28. These 6,154 elements represent eight species of four genera:

Anchignathodus isarcicus (Huckriede)
A. julfensis Sweet, n. sp.
A. typicalis Sweet?
Ellisonia gradata Sweet
E. teicherti Sweet
E. spp.
Neogondolella carinata carinata (Clark)
N. carinata subcarinata Sweet n. subsp.
N. carinata subcarinata?
N. orientalis (Barskov and Koroleva)
Xaniognathus sp. cf. *X. elongatus* Sweet

One of these species, *Anchignathodus julfensis* n. sp. has not been recognized previously and is named in this report. In addition, a previously undescribed subspecies of *Neogondolella carinata* (Clark) is recognized and named *N. carinata subcarinata* n. subsp.

Conodont elements in our collection from Kuh-e-Ali Bashi are unaltered, amber in color, and generally quite well preserved. A large number of the gondolelliform elements, which dominate the collections, are complete and unbroken; however, only a few of the ramiform elements are undamaged and a majority of the specimens at hand are faintly etched or pitted surficially. Several specimens (*e.g.*, Pl. 12, figs. 3, 13) have irregular tubular structures attached to them which we interpret as attached foraminifiers. From these features of preservation we conclude that the elements at hand were exposed to solution, currents, and to the activities of other organisms for some time after they accumulated on the sea floor.

AGE AND CORRELATION OF THE ALI BASHI FORMATION

The Age and correlation of the "Induan" beds of Soviet Dzhulfa have been a source of controversy for nearly a century. The views and interpretations of earlier researchers have been outlined in the previous chapter on "History of Research." It is the large monographic study of the stratigraphy and paleontology of these strata in Soviet Dzhulfa, edited by Ruzhentsev and Sarycheva (1965), that needs to be considered at this time. These Soviet authors came to the conclusion that the beds with *Tompophiceras* through those with *Paratirolites* are Early Triassic in age and belong to the Induan Stage of Kiparisova and Popov (1956, 1961, 1964). They based their arguments on age assignment entirely on ammonoids. They summarized their views as follows (translation of Ruzhentsev and Sarycheva, 1965, by D.A. Brown, 1968: 107–108):

"In these deposits we have recognized four stratigraphical levels (in ascending order): 1) beds with *Tompophiceras*, 2) beds with *Dzhulfites*, 3) beds with *Bernhardites*, and 4) beds with *Paratirolites*.

"In the beds with *Tompophiceras*, a new species, *T. transcaucasium* Shevyrev has been identified. Representatives of the genus *Tompophiceras* had so far been known only in Verkhoyansk, where they occur together with *Otoceras boreale* Spath, *O. indigirense* Popov, and *Glyptophiceras pascoei* Spath (Popov, 1961), that is, with species which, in East Greenland, are found at the base of the Lower Triassic. Therefore, we may consider the Dzhulfian beds with *Tompophiceras*, with reasonable confidence, as the stratigraphic equivalents of the zone of *Otoceras woodwardi* and *Ophiceras commune* of the above scale.

"The beds with *Dzhulfites* contain unusual forms of ceratites, unknown in other regions which, naturally, are difficult to correlate.

"In the overlying beds with *Bernhardites* this genus is represented by the species *B. radiosus* (Frech), which is also characteristic of the lower *Ceratite* limestone of the Salt Range. The latter, on its faunal assemblage, is correlated with the zone of "*Celtites*" *radiosus* of Spath and the zone of *Proptychites rosenkrantzi* of Kummel. On this basis the beds with *Bernhardites* may be considered as the equivalent of the zone of *Proptychites rosenkrantzi*, and the underlying beds with *Dzhulfites* may provisionally be correlated with the zone of *Vishnuites decipiens*.

"The beds with *Paratirolites* are also peculiar in their faunal relationships; ceratites unknown in other regions are found in them. The clarification of the position of these beds in the stratigraphic scale is served by two circumstances. First, the clear genetic association of the genera *Paratirolites* and *Abichites* with the older *Dzhulfites* and *Bernhardites* opposes any stratigraphic break between the third and fourth series of beds. Second, Sh.A. Azizbekov 1961, p. 83), citing determinations by L.D. Kiparisova, records from the deposits occurring in Nakhichevansk ASSR directly above the beds with *Paratirolites*, such species as *Claraia stachei* Bittner, *C. aurita* Hauer and *Proptychites discoides* Waagen. The last species is also known from the lower *Ceratite* limestone of the Salt Range. Consequently, the beds with *Paratirolites* may also be correlated with the zone of *Proptychites rosenkrantzi*.

"Thus, the palaeontologically characterized Lower Triassic deposits of Trans-Caucasia correspond precisely, in our opinion, with the lower half of the Induan Stage. At the transition on the zonal scale they embrace the entire *Otoceras* Horizon, that is, the zones of *Otoceras woodwardi* and *Ophiceras commune*, and half of the *Gyronites* Horizon with the zones of *Vishnuites decipiens* and *Proptychites rosenkrantzi*. Such an age determination for these beds is in considerable degree new, because several authors (Spath, 1934; Kummel, 1957, etc.) were inclined to accept the *Paratirolites* beds up to the zone of *Anasibirites multiformis*, recognized in the lower part of the Olenekian Stage."

The critical genera in the above discussion are *Tompophiceras*, *Dzhulfites*, *Bernhardites*, and *Paratirolites*, which are represented in the Ali Bashi Formation at Kuh-e-Ali Bashi, and are discussed in detail in the chapter on "Systematic Paleontology." A summary of their stratigraphic implications is given here.

The specimens assigned to *Tompophiceras* by Shevyrev (*in* Ruzhentsev and Sarycheva, 1965) are not conspecific with *Tompophiceras fastigatum* Popov from Siberia. Shevyrev had only eight fragmentary specimens, whereas our collections contain a large number of specimens of this form. Fastigation of the venter in *Tompophiceras fastigatum* Popov is present on the outer volution. We have specimens from the Ali Bashi Formation that are fastigate at a diameter of 13 mm. For these reasons we establish the new genus *Iranites* for these forms in the Ali Bashi Formation and the corresponding forms in Soviet Dzhulfa.

Dzhulfites Shevyrev is a synonym of *Paratirolites.* It differs from *Paratirolites* only in whorl section, the sutures being almost identical.

Ribbed, evolute ammonoids of the type Shevyrev placed in his genus *Bernhardites* are not uncommon in Late Permian and Early Triassic strata. They are very difficult to identify and differentiate. As a consequence, precise age determination is tenuous at best. Shevyrev (*in* Ruzhentsev and Sarycheva, 1965) selected *Celtites radiosus* Koken (*in* Frech, 1905) as the type of his new genus *Bernhardites.* This species was stated to have come from the Lower Ceratite limestone of the Salt Range, West Pakistan. However, Kummel's field experience in the Triassic formations of the Salt Range demonstrates that specimens of the species actually occur in the overlying Ceratite marl. It is our contention that the specimens assigned to *Bernhardites* from the "Induan" of Soviet Dzhulfa are not congeneric with "*Celtites*" *radiosus* Koken of the Salt Range.

Until recently *Paratirolites* was known only from the "Induan" of Soviet Dzhulfa and the Ali Bashi Formation of northwestern Iran. Recently Tozer (1969) has pointed out that the specimen from Madagascar assigned by Diener (1914) to *Xenodiscus douvillei* Diener is a paratirolitid. Unfortunately, no stratigraphic data are available for this specimen. Taraz (1969) reported *Paratirolites* from Abadeh in central Iran, and Teichert collected specimens from this locality in 1970. But Taraz's faunal list that includes this genus, in addition to *Pseudogastrioceras, Dzhulfites, Abichites,* and *Bernhardites,* is for a unit 19 m (62 feet) thick which probably represents the equivalent of the entire Ali Bashi Formation.

In the monograph edited by Ruzhentsev and Sarycheva (1965) an attempt was made to establish the age of the lower part of the "Induan" in Soviet Dzhulfa on the basis of the presence, in sequence, of four ammonoid genera, namely *Tompophiceras, Dzhulfites, Bernhardites,* and *Paratirolites.* With exception of *Paratirolites,* we consider these generic identifications to be wrong. In addition, none of these taxa unequivocally indicates a Late Permian or Early Triassic age.

Several additional genera of ammonoids, representatives of which we collected from the Ali Bashi Formation, are of considerable importance in assessing the age of the formation. Among these, the most interesting are "*Pleuronodoceras,*" "*Pseudotirolites,*" and "*Pseudostephanites.*" These genera were first illustrated, though not formally established, by Chao (1965) from highest Permian strata, the Changhsing limestone, of eastern China. The Changhsing district in northern Chekiang was selected as type locality of the Changhsingian Stage by Furnish and Glenister (*in* Kummel and Teichert, 1970). The remaining newly discovered genera are *Strigogoniatites, Neoaganides,* and *Urartoceras,* all of which are well-known from Permian strata but most of which have long ranges. Only six species of *Strigogoniatites* have been recorded so far, all of Permian age. On the evidence of these six species, acuteness of the venter appears to develop at progressively younger stages through Permian time. One of our specimens from the Ali Bashi Formation has a well-developed acute venter at a diameter of 18 mm. On the basis of earlier observations on species of this genus, this would suggest that our forms are very late Permian in age.

Neoaganides n. sp. was recognized by Teichert and Kummel on the basis of a single specimen. Our collections from the underlying Julfa beds contain a conspecific specimen now being studied by W.M. Furnish and B.F. Glenister. The specimen of *Urartoceras* sp. indet. from the Ali Bashi Formation is an interesting find. This genus is quite common in the underlying *Vedioceras* Zone in the Dzhulfian of Soviet Dzhulfa.

Phisonites is known only from the Ali Bashi Formation in Iran and in equivalent strata across the Aras River in Soviet Dzhulfa. The beds containing this genus were included in the Dzhulfian by Ruzhentsev and Sarycheva (1965), but we consider that they are more properly included in the Ali Bashi Formation.

Thus, our analysis of the ammonoid fauna of the Ali Bashi Formation leads us to the conclusion that it does not contain a single genus that can be considered as being Triassic in age.

The conodonts add significant data bearing on the question of the age of the Ali Bashi Formation. From Table 7 it is clear that *Neogondolella carinata* (Clark) is the dominant member of the conodont fauna of the Ali Bashi Formation, but representatives of *Ellisonia gradata* Sweet, *E. teicherti* Sweet, and, possibly, *Anchignathodus typicalis* Sweet are present from near or below the base of the formation to, or well above, its top. This assemblage of species, which continues to a level 13.5 m above the base of the Elikah Formation, is characteristic of the *Anchignathodus typicalis* Zone (Sweet, 1970b; Sweet *et al.*, 1971), which "straddles" the Permian-Triassic boundary in Pakistan (Sweet, 1970b), Kashmir (Sweet, 1970a), and East Greenland (Sweet, unpublished MS).

In the Salt Range and the Trans-Indus ranges of Pakistan, the top of the *Anchignathodus typicalis* Zone is in the Kathwai Member of the Mianwali Formation, a few feet below the highest occurrence of *Ophiceras*. In one section (Chhidru A, Kummel and Teichert, 1970), it occurs 9.6 feet above the lowest occurrence of that distinctive Early Triassic ammonoid. Conodonts characteristic of the *A. typicalis* Zone are also present at various levels in the upper 12 feet or so of the subjacent Chhidru Formation at four places in the Salt Range and Trans-Indus ranges, but the base of the *A. typicalis* Zone has not been located in those sections.

In the section of Permian and Triassic rocks at Guryul Ravine, Kashmir (Teichert, Kummel, and Kapoor, 1970; Sweet, 1970a; Nakazawa *et al.*, 1970), *Anchignathodus typicalis* and *Ellisonia teicherti* range from 29 feet below to 39 feet above the level at which Teichert, Kummel, and Kapoor (1970) placed the Permian-Triassic boundary. Nakazawa and his colleagues reported *Claraia, Otoceras, Ophiceras,* and *Proptychites* from various levels within the upper 39 feet of the *A. typicalis* Zone at Guryul Ravine, and the highest record of the *A. typicalis* conodont fauna is at about the same level as the highest *Ophiceras* reported from that section. The base of the *A. typicalis* Zone has not been located in the Guryul Ravine section, for the lowest conodont-bearing sample known there yields the zonal index species, *Ellisonia teicherti* and *E. triassica*.

In the Salt Range and Guryul Ravine sections, the *Anchignathodus typicalis* Zone is succeeded stratigraphically by a sequence of strata in which specimens of *Neogondolella carinata* (Clark) dominate conodont collections, and indexes to the *A. typicalis* Zone (*e.g., Anchignathodus typicalis, Ellisonia teicherti*) are absent. These strata were included by Sweet (1970a, 1970b) in a *Neogondolella carinata* Zone, which may or may not have stratigraphic utility in other sections. That is, the index species of the *N. carinata* Zone is also abundantly represented in the subjacent *A. typicalis* Zone and the boundary between the two is drawn at the level of disappearance of *A. typicalis* and its fairly constant companion, *Ellisonia teicherti*.

As noted previously, representatives of *Ellisonia teicherti* and, possibly, of *Anchignathodus typicalis* have been collected from as high as 13.5 m above the base of the Elikah Formation at Locality 1 (OSU section 69SA) (Table 7) in the Julfa region. Elikah strata above 13.5 m have produced only a few, mostly fragmentary, conodont elements. None of these is referable to *Neogondolella carinata.* Thus we cannot directly correlate the 13.5 m level at Locality 1 with the top of the *A. typicalis* Zone in either the Kashmir or the Salt Range sections. However, the 13.5 m level may be very close to the top of the *A. typicalis* Zone, because well-preserved specimens of *Anchignathodus isarcicus* (Huckriede) have been recovered from three samples in the lower 4.5 m of the Elikah Formation. Representatives of this same species occur about 5 feet above the lowest occurrence of *Ophiceras* in three sections in Pakistan (Sweet, 1970b) and a comparable distance below the highest level from which *A. typicalis* and *E. teicherti* have been found in those sections. In addition to suggesting a general correlation between the top of the *A. typicalis* Zone of Pakistan and Kashmir with the 13.5 m level in the Elikah Formation at Julfa Locality 1, the occurrence of *A. isarcicus* in the lower 4.5 m of that formation suggests not only that the sampled portion of the Elikah is entirely Triassic in age, but also that it represents essentially the same part of the Lower Triassic as the Kathwai Member of the Mianwali Formation of Pakistan. *A. isarcicus* also defines a thin interval near (but not at) the base of the Werfen Formation in the southern Alps of northern Italy (Staesche, 1964).

An important result of Sweet's study of Permian and Triassic conodonts from the Julfa region is location of the base of the *Anchignathodus typicalis* Zone. We define that level here at the lowest occurrence of *Neogondolella carinata* (Clark), which appears for the first time in the lowest samples from the Ali Bashi Formation at Localities 1 and 4. *Ellisonia teicherti* and fragmentary specimens reminiscent of *A. typicalis* appear 0.2 m above the base of the Ali Bashi Formation at Locality 4, and neither these species nor *N. carinata* are represented in any of the few samples we have from strata older than the Ali Bashi Formation in Iran or nearby Soviet Transcaucasia. We feel this boundary to be an especially significant one, for it represents the level of evolutionary transition from *Neogondolella orientalis* (Barskov and Koroleva) to *N. carinata* (Clark).

It is of interest to note that the *Anchignathodus typicalis* Zone, as now defined, includes not only the latest Permian Changhsingian Stage of Furnish and Glenister (1970), but also much, if not all, of the earliest Triassic Griesbachian Stage of Tozer (1967). Clearly, conodonts were either far less sensitive chronometers than ammonoids in latest Permian and earliest Triassic time or the *A. typicalis* Zone has been too broadly conceived. That the latter is probably the case is suggested by some of the new material described in this report. That is, in *Neogondolella carinata* (Clark), the most abundantly represented conodont species of the Ali Bashi Formation, we can distinguish two vertically segregated but morphologically intergradational subspecies. *N. carinata subcarinata* Sweet, n. subsp., ranges from the base to the top of the Ali Bashi Formation (*i.e.,* essentially through the Changhsingian Stage), whereas *N. carinata carinata* makes its first appearance 4.5 m below the top of the Ali Bashi Formation, is represented by a single Elikah specimen (sample 67GH-28) from near the top of the *A. typicalis* Zone in Iran, and is the only subspecies of *N. carinata* represented in the largely Lower Triassic *A. typicalis* faunas of Pakistan and Kashmir (Sweet, 1970a, 1970b). Possible division of the present *A. typicalis* Zone into two major parts is thus suggested, as is further subdivision of these by segregation of intervals with *Anchignathodus julfensis* Sweet, n. sp., and *A. isarcicus* (Huckriede).

We do not at this time propose formally to dismember the *Anchignathodus typicalis* Zone along the lines just suggested, for we do not know that the divisions outlined would have biostratigraphic utility even in sections close to the Julfa region. However, if additional material from other regions supports no more than a division into two parts, a lower one characterized by *Neogondolella carinata subcarinata* and an upper distinguished by *N. carinata carinata,* some light would be shed on currently divergent conclusions about correlation of the uppermost part of the Chhidru Formation of Pakistan. In fact, even without division of the *A. typicalis* Zone, we can now set at least a lower limit for the age of the uppermost part of that formation, and this should help in determining the magnitude of the stratigraphic gap that is supposed to separate Permian and Triassic rocks in the Salt Range and Trans-Indus ranges of Pakistan.

From their study of the worldwide distribution of species of the ammonoid *Cyclolobus,* Furnish and Glenister (1970) concluded that strata referable to the uppermost Permian Changhsingian Stage are missing in Salt Range sections, even though no specimens of *Cyclolobus* have been collected from the uppermost 36 feet or so of the Chhidru Formation, which is believed to be the youngest Permian unit in the Salt Range. On brachiopod evidence from the Chhidru and superjacent Mianwali Formation, Grant (1970) concluded that the Chhidru is most likely Guadalupian and the overlying Kathwai Member of the Mianwali Formation probably Dzhulfian in age. With respect to Furnish and Glenister's conclusion, we point out that *Neogondolella carinata carinata* dominates a sample (K4-2) from about 12 feet below the top of the Chhidru Formation at Chhidru (Sweet, 1970b), and it is now known that *N. carinata* ranges no lower than the base of the Ali Bashi Formation of Iran which probably represents the base of the Changhsingian Stage. Thus, strata of the Changhsingian may well be present in the upper Chhidru Formation, even though diagnostic ammonoids are lacking. Moreover, if *N. carinata carinata* has the same stratigraphic distribution in Iran and Pakistan, the upper beds of the Chhidru Formation would correlate with the uppermost 4.5 m of the Ali Bashi Formation of the Julfa region (*i.e.,* with the Paratirolites limestone of Stepanov *et al.,* 1969, and of this report). In short, the upper beds of the Chhidru Formation of the Salt Range and Trans-Indus ranges may be of very latest Permian age and the Permian section of Pakistan may well be virtually complete.

Rebuttal to Grant's (1970) suggestion that the Chhidru Formation is most likely Guadalupian in age is implicit in the foregoing discussion. If by suggesting a Dzhulfian age for the overlying Kathwai Member of the Mianwali Formation, Grant was following the definition of that stage given by Ruzhentsev and Sarycheva (1965) (*i.e., Araxilevis* through *Phisonites* beds), then conodont evidence now at hand is contradictory. *Neogondolella carinata,* which occurs in the upper 12 feet or so of the Chhidru, appears at the base of the Ali Bashi Formation in the Julfa region, and the base of the Ali Bashi is essentially the same as the base of the uppermost Dzhulfian *Phisonites* beds *sensu* Ruzhentsev and Sarycheva. Thus the *Phisonites* beds are the lowest Dzhulfian unit with which the Kathwai or immediately underlying upper Chhidru beds could possibly be correlated. However, *N. carinata carinata,* the subspecies represented in the uppermost Chhidru and Kathwai, does not appear in Iran until the base of the *Paratirolites* beds, some 12 m above the top of the Dzhulfian *sensu* Ruzhentsev and Sarycheva. Furthermore, *Anchignathodus isarcicus* in both the lower unit of the Kathwai and the basal 4.5 m of the Elikah suggests correlation of these units, not a correlation of the Kathwai of Pakistan with beds in Iran or Soviet Transcaucasia as old as the *Phisonites* beds of the lower Ali Bashi Formation.

While the evidence for a Late Permian age of the Ali Bashi Formation, based on detailed analysis of the ammonoid and conodont faunas, may be considered as conclusive, it is worth pointing out that this conclusion is strongly supported by the study of other faunal elements. All four species of corals described by us from the Ali Bashi Formation were found by us in the underlying Julfa beds. The single bryozoan specimen found in the Ali Bashi is a member of the typically Paleozoic family

Stenoporidae. Brachiopods are represented by fewer species than in the "Induan" of the Dzhulfa area, but *Araxathyris araxensis minor* Grunt was reported from the upper Dzhulfian by Sarycheva, Sokolskaya, and Grunt (*in* Ruzhentsev and Sarycheva, 1965).

Most of the nautiloid genera reported by us from the Ali Bashi Formation are characteristic Late Paleozoic forms, with the possible exception of *Syringonautilus,* which was not previously known from pre-Triassic rocks. The typical Permian aspect of the ostracod fauna of the Ali Bashi Formation has already been stressed. The crinoids, represented by stems only, clearly were Paleozoic types.

All in all, it seems to us that the fauna of the Ali Bashi Formation of Kuh-e-Ali Bashi and of the corresponding beds in Transcaucasia is composed of populations that survived from the preceding Dzhulfian. On the whole these populations were impoverished with respect to species and very few new forms were added, none of them suggestive of demonstrably post-Paleozoic affinities.

SYSTEMATIC PALEONTOLOGY

In the following descriptions MCZ indicates Museum of Comparative Zoology, Harvard University; KU University of Kansas Museum of Invertebrate Paleontology; OSU Orton Museum of Geology, The Ohio State University. The descriptions of Conodontophorida are by Sweet and reference to them should be made as "Sweet *in* Teichert, Kummel, and Sweet, 1973." All other descriptions are by Teichert and Kummel and the correct reference is "Teichert and Kummel *in* Teichert, Kummel, and Sweet, 1973."

Phylum **COELENTERATA**

Class **ANTHOZOA** Ehrenberg, 1834

Subclass **TABULATA** Milne-Edwards and Haime, 1850

Order *FAVOSITIDA* Sokolov, 1950

Family MICHELINIIDAE Waagen and Wentzel, 1886

Subfamily MICHELINIINAE Waagen and Wentzel, 1886

Genus *Michelinia* de Koninck, 1841

Type species, *Calamopora tenuisepta* Phillips, 1836

Discussion. Chudinova (*in* Ruzhentsev and Sarycheva, 1965: 35) did not record any species of *Michelinia* from the "Induan" of the Soviet Dzhulfa area but reported two species, *M. parva* and *M. nana,* from the Dzhulfian and two others, *M. miranda* and *M. vesiculosa,* from Guadalupian strata of that area. Other species of *Michelinia* were reported from localities in the Transcaucasus. Gräf (1964) described as *Michelinia indica* Waagen and Wentzel a specimen from Dizdere, a locality somewhere south or southeast of Julfa, the exact position of which we find difficult to identify. No stratigraphic details are known.

Michelinia vesiculosa Chudinova

Plate 1, figures 8–10

Michelinia vesiculosa Chudinova, *in* Ruzhentsev and Sarycheva, 1965: 152, pl. 8, fig. 2.

Discussion. Our collections contain one fairly large colony of *Michelinia* whose longest diameter is about 80 mm. The diameter of the corallites varies from about 5 to 7.5 mm. They are subhexagonal in transverse section and essentially straight. Wall pores are present, but their density is difficult to determine; they are probably up to 0.5 mm in diameter. Septa are absent, but septal tubercles are present. Tabulae are strongly convex upward and somewhat variable in distance between about 0.5 and 3.0 mm.

We assign this specimen to *Michelinia vesiculosa* because of size of corallum and corallites and nature of the tabulae, although Chudinova (*in* Ruzhentsev and Sarycheva, 1965: 152) reports this species only from the Gnichik Formation of early Guadalupian age in the Transcaucasus. Of the two "Induan" species, *M. parva* and *M. nana,* described by Chudinova from the Transcaucasus, *M. parva* has concave, or at least less strongly convex, tabulae; and *M.*

nana, a very small corallum consisting of only two or three corallites.

Occurrence. Loc. 1, 1 m above base of bed 19.

Repository. MCZ 9409.

Subclass **RUGOSA** Milne-Edwards and Haime, 1850

Order *STREPTELASMATIDA* Wedekind, 1927

Family PLEROPHYLLIDAE Koker, 1924

Genus *Plerophyllum* Hinde, 1890

Type species, *Plerophyllum australe* Hinde, 1890

Plerophyllum is common in Permian rocks in Asia and Australia (Schindewolf, 1942) and is among the few Late Permian survivors of the Rugosa. Ilina (1962, 1965) described the following species from the Ali Bashi Formation equivalents ("Induan" Stage) of the Transcaucasus: *P. armenicum, P. cuneatum, P. differentiatum, P. dzhulfense. P. dzhulfense* is the only one of these species that extends from the Dzhulfian into the "Induan." All four species occur in the Soviet Dzhulfa area at Dorasham 1 and 2.

Plerophyllum dzhulfense Ilina

Plate 1, figures 1–7

Plerophyllum dzhulfense dzhulfense Ilina, 1962: 75–76, pl. 1, figs. 4, 5 (Engl. transl., 1964: 1611–1612, pl. 1, figs. 4, 5).

Plerophyllum dzhulfense Ilina, 1965: 47–52; pl. 3, fig. 9; pl. 4, figs. 1–11; pl. 5, figs. 1–5.

Discussion. In our collections the genus *Plerophyllum* is represented by six small coralla, not much more than about 15 mm long. They are slightly curved, slowly expanding. We are placing these specimens in *Plerophyllum dzhulfense* because they seem to be closer to this species than to any of the other three described by Ilina from the Transcaucasus.

We are figuring four cross sections (Pl. 1, figs. 2, 4, 6, 7) from three different specimens, the larger of which (Pl. 1, fig. 7) is about 14.5 mm wide. One of them (Pl. 1, fig. 2) is perhaps somewhat similar to *Plerophyllum differentiatum* because most major septa are tapering inward rather than being rhopaloid in transverse section, but Ilina has also illustrated specimens of *P. dzhulfense* having septa of this kind (Ilina, 1965, pl. 4, fig. 11b).

One of the figured specimens (Pl. 1, fig. 6) seems to us to be closer to *P. dzhulfense,* the other (Pl. 1, fig. 4), closer to *P. differentiatum.* In the specimen illustrated in Figure 4, the number of septa in the alar quadrants is two less than in the counter quadrants and the alar and counter-lateral septa are distinctly rhopaloid whereas the cardinal and counter septa are not. In the specimen illustrated on Plate 1, figure 6, none of the major septa is rhopaloid, except the cardinal septum, which is only very weakly rhopaloid.

It should not be overlooked that these characters vary in other species of *Plerophyllum.* Thus, both Gerth (1921, pl. 146, figs. 16, 17) and Schindewolf (1942, text–figs. 45c, d) illustrated specimens of *P. radioforme* Gerth having rhopaloid as well as nonrhopaloid septa. This species occurs in Timor in the Basleo Formation of Guadalupian age. It closely resembles *P. dzhulfense,* but no detailed comparisons can be made on the basis of our limited material. Gräf (1964) described a species from the Permian of the Abadeh area in central Iran as *P. radiciforme* which may well be conspecific with either *P. dzhulfense* or *P. differentiatum.*

Occurrence. One specimen (MCZ 9404) from Loc. 2, 70 cm above base of Ali Bashi Formation; 1 specimen (MCZ 9405) from Loc. 2, 1 m above base of Ali Bashi Formation; 1 specimen (MCZ 9406) from Loc. 3, 4.5 m above base of Ali Bashi Formation; 3 specimens (KU 73289, 73290, 73292) from Loc. 4, bed 3.

Respository. MCZ 9404 (Pl. 1, figs. 5–7), MCZ 9405 (Pl. 1, figs. 3–4), MCZ 9406 (Pl. 1, figs. 1–2). Unfigured specimens KU 73289, 73290, 73292.

Genus *Ufimia* Stuckenberg, 1895

Type species, *Ufimia carbonaria* Stuckenberg, 1895

Ufimia resembles *Plerophyllum* but differs in that the cardinal septum is short in the adult stage. Some authors, *e.g.*, Schindewolf (1942) and Flügel (1968), consider it to be a subgenus of *Plerophyllum.* Ilina (1965) described two species as *Ufimia elongata* (Gerth) and *U. alternata* (Huang). Both species occur in the Gnishik Formation of Guadalupian age of the Transcaucasus, though not in the Dzhulfa region. The stratigraphic range of the genus is Middle Devonian to Upper Permian and it occurs in Europe, Asia, and Australia (Ilina, 1965: 71).

Ufimia sp.

Plate 2, figures 3, 4, 7, 8

Discussion. Our collections contain four specimens which we assign to *Ufimia*, but which do not warrant a specific assignment. Specimen KU 73282 is a fragment that is 8 mm long and 8.5 mm wide at its proximal end. Most septa taper inwardly and only some are weakly rhopaloid in cross section. The cardinal septum is less than half as long as the alar septa. Specimen no. MCZ 9407 is similar in all respects. The corallum is 1.4 mm long (Pl. 2, fig. 3), and the illustration on Plate 2, figure 4 represents a cross section 10 mm from the tip of this corallum. Here, too, the cardinal septum is a little less than half as long as the alar septa.

There is no doubt that both specimens belong to the same species, and they are probably conspecific with one of the two Guadalupian species described by Ilina (1965) from the Transcaucasus, but on the basis of our limited material we are unable to decide with which.

The type material of *Ufimia elongata*, originally assigned to *Tachylasma* by Grabau (1928: 69), came from cherty limestone of Permian (probably Guadalupian) age in Anhwei Province, eastern China. The specimens from the Transcaucasus and Kuh-e-Ali Bashi may well be conspecific with the Chinese specimens, although in two transverse sections figured by Grabau (1928, pl. 1, figs. 13a, d) some of the major septa, especially the counter-laterals, are more distinctly rhopaloid than in any of the specimens considered here.

Occurrence. 1 specimen (MCZ 9407) from Loc. 2, 7.5 m above base of Ali Bashi Formation (Pl. 2, figs. 3, 4); 1 specimen (KU 73282) from Loc. 2, 4.5 m above base of Ali Bashi Formation (Pl. 2, figs. 7, 8); 1 specimen from Loc. 2, 13.5 m above base of Ali Bashi Formation (KU 73283), 1 specimen (KU 73291) from Loc. 4, bed 3.

Repository. MCZ 9407 (Pl. 2, figs. 3, 4), KU 73282 (Pl. 2, figs. 7, 8). Unfigured specimens, KU 73283, KU 73291.

Genus *Pleramplexus* Schindewolf, 1940

Type species, *Pleramplexus similis* Schindewolf, 1940

The genus *Pleramplexus* has been thoroughly discussed in recent publications by Ilina (1965) and by Flügel (1970). It includes members of the family Plerophyllidae having fully developed major septa in early growth stages only. In the mature stage, the septa are much reduced in size. According to Flügel (1970), the genus is known from the Permian of northern Iran, the Transcaucasus, Timor, Sicily, and perhaps Hungary. In the Transcaucasus and in the Alborz Mountains of Iran, the genus occurs only in rocks of Dzhulfian age.

Pleramplexus leptoconicus (Abich)

Plate 2, figures 1, 2, 5, 6

Clisiophyllum leptoconicum Abich, 1878: 87, pl. 2, figs. 7, 7a.

Pleramplexus leptoconicus (Abich), Flügel, 1968: 289–291, text-fig. 5, pl. 25, fig. 3. (Contains full synonymy.)

Description. Pleramplexus leptoconicus is the predominant species in our coral collections from the Ali Bashi Formation, where it is represented by eight specimens. It has been well described by Heritsch (1937), Ilina (1962, 1965), and by Flügel (1968). On the basis of 28 peels of transverse sections available to us, which measure from 3.9 to 15.0 mm in diameter, the Ali Bashi form agrees in every respect with the Dzhulfian forms described by Ilina and by Flügel. The maximum diameter of any one corallum is 15 mm.

The protosepta are well developed at a diameter of the corallum of about 6 mm

(Pl. 2, fig. 5) when the total number of major septa is about 13. At a diameter of 14 mm (Pl. 2, fig. 6), the number of major septa is 20. These are of subequal length with cardinal, alar, and counter-lateral septa only slightly more emphasized than the other septa. A minor septum is inserted between each two major septa. In another specimen measuring 14 mm in cross section, the number of major septa is 26. The counter-laterals are the longest as the counter septum is very short. From this area, the septa become progressively shorter through the counter-lateral quadrants; the alar septa are slightly longer, and the septa in the alar quadrants are again shorter, and the cardinal septum is no longer, but very slightly thicker, than the septa in the alar quadrants.

In several sections the septa appear slightly wavy as described for this species by Ilina (1962, 1965). In intermediate growth stages, some of the major septa tend to become rhopaloid in transverse section, as is also shown in some specimens illustrated by Ilina (1965), although there is little regularity in the position of the rhopaloid septa (compare Ilina, 1965, pl. 14, fig. 2, and pl. 15, fig. 4b). The same feature was earlier demonstrated by Heritsch (1937, *e.g.*, pl. 2, fig. 10).

Discussion. The specimens from the Ali Bashi Formation agree in every respect with the many specimens of *Pleramplexus leptoconicus* described and illustrated from the Dzhulfian of the Transcaucasus by Heritsch (1937) and by Ilina (1962, 1965), and from the Nesen Formation of the Alborz Mountains by Flügel (1968). In regard to size, they are intermediate between the maximum diameter of 11 mm noted by Flügel and the maximum diameter of 22 mm given by Ilina.

This species seems to be very similar to the type species of *Pleramplexus*, *P. similis* Schindewolf, from the Basleo beds of Timor (see especially Schindewolf, 1942), which seems to differ mainly in having a short cardinal septum. A specimen described under this name by Gräf (1964) from the vicinity of Abadeh is possibly conspecific with *P. leptoconicus*.

Occurrence. 1 specimen (KU 73284) from Loc. 3, 4.5 m above base of Ali Bashi Formation; 1 specimen (KU 73285) from Loc. 3, 7.5 m above base of Ali Bashi Formation; 2 specimens (KU 73293, 73294) from Loc. 4, bed 5; 5 specimens (MCZ 9408; KU 73286, 73287, 73288) from unspecified localities.

Repository. MCZ 9408 (Pl. 2, figs. 1, 2), KU 73288 (Pl. 2, figs. 5, 6). Unfigured specimens KU 73284, 73285, 73286, 73287, 73293, 73294.

Phylum **BRYOZOA**

Class **GYMNOLAEMATA** Busk, 1852

Order *TREPOSTOMATA* Ulrich, 1882

Family STENOPORIDAE Waagen and Wentzel, 1886

Genus and species indeterminate

Plate 2, figure 10

Description. A fragment of an annulated orthocone, probably *Neocycloceras* sp. indet., and probably all phragmocone, is almost completely encrusted by a trepostomatous bryozoan. The specimen was submitted to R. S. Boardman, U. S. National Museum, for examination. He reported that it probably belongs to the family Stenoporidae, but that its generic affinities could not be identified with certainty. He stated (letter to Teichert, 28 May 1971) that the occurrence of a stenoporid of this age was, in itself, of considerable interest. The range of the family Stenoporidae is stated as Silurian to Permian by Bassler (1953: 101).

Discussion. Morozova (*in* Ruzhentsev and Sarycheva, 1965) did not report occurrence of Trepostomata in the equivalents of the Ali Bashi Formation in the Dorasham section or from equivalents of the Julfa beds. Obviously, the Ali Bashi specimen is a very late straggler of the family, and it is hoped that more and better-preserved specimens will be found in the future.

Occurrence. Loc. 3, 4.5 m above base of Ali Bashi Formation.

Repository. MCZ (no number).

Phylum BRACHIOPODA

Class **ARTICULATA** Huxley, 1869
Family ATHYRIDIDAE McCoy, 1844
Genus *Araxathyris* Grunt *in* Ruzhentsev and Sarycheva, 1965
Type species, *Spirigera protea* Abich, 1878

Araxathyris araxensis minor Grunt *in* Ruzhentsev and Sarycheva, 1965
Plate 2, figures 11–16

We are indebted to G. A. Cooper (letter to Kummel, 13 February 1970) for the identification of our brachiopod specimens, two of which are illustrated here. *Araxathyris araxensis minor* is the most common form in the "Induan" beds of Soviet Dzhulfa as reported by Ruzhentsev and Sarycheva (1965).

Occurrence. All specimens within 4.5 m from base of Ali Bashi Formation.

Repository. MCZ 9828 (Pl. 2, figs. 11–13), MCZ 9827 (Pl. 2, figs. 14–16). Unfigured specimens MCZ 9829–9833, KU 73315, 73316 (Loc. 3, at 4.5 m), KU 73321–73329 (Loc. 4, bed 2), KU 73317–73320 (Loc. 4, bed 3).

Phylum MOLLUSCA

Class **BIVALVIA** Linné, 1758
Subclass **PALAEOTAXODONTA** Korobkov, 1954
Family NUCULANIDAE Adam and Adam, 1958
Genus *Phestia* Chernyshev, 1951
Type species, *Leda inflatiformis* Chernyshev, 1939

Phestia sp. indet.
Plate 2, figure 9

Kummel and Teichert are indebted to N. D. Newell (letter to Kummel, 16 December 1969) for the identification of the only bivalve collected by them from the Ali Bashi Formation. No bivalves were reported from the same stratigraphic interval in Soviet Dzhulfa (Ruzhentsev and Sarycheva, 1965). The presence of the genus *Phestia* adds little to determination of the age of the Ali Bashi Formation as it ranges from Devonian through Lower Triassic.

Occurrence. Float.

Respository. MCZ 18005.

Class **CEPHALOPODA** Cuvier, 1798
Order *ORTHOCERIDA* Kuhn, 1940

Included in our collections from the Ali Bashi Formation are 13 conch fragments of orthocerids, which we are assigning to three genera.

Superfamily PSEUDORTHOCERATACEAE Flower and Caster, 1935
Family PSEUDORTHOCERATIDAE Flower and Caster, 1935

We here follow the systematic treatment suggested by Sweet (*in* Teichert *et al.*, 1964). Barskov (1963) proposed to raise the superfamily Pseudorthocerataceae to the rank of an order that he named Pseudorthoceratida and proposed to place it in the superorder Actinoceratoidea. However, it seems to us that the structures of both endosiphuncular and cameral deposits of the pseudorthoceratids are significantly different from those of actinocerids, although some pseudorthoceratid genera are considered to be homeomorphs of actinocerids (Flower, 1957).

Genus *Dolorthoceras* Miller, 1931
Type species, *Dolorthoceras circulare* Miller, 1931

?*Dolorthoceras* sp. indet.
Plate 9, figure 6

Description. One fragment of an internal mold of a phragmocone, 39 mm long, consisting of 16 camerae; cross section somewhat elliptical, longest diameter of conch increasing from 6 mm at adapical end to 11.5 mm at the adoral end. It is not possible to measure accurately the shorter conch diameter because the specimen is attached to the rock with one of its broad sides. Sutures form very shallow lobes across the exposed broad side of specimen. In the first of the camerae, cameral deposits are present, but their structure cannot be determined. The siphuncle seems to be in a near-central position.

Remarks. Up till now, no representatives of *Dolorthoceras* seem to have been reported from rocks of Late Permian age.

The stratigraphic range of the genus is given by Sweet (*in* Teichert *et al.*, 1964) as Lower Devonian to Lower Permian, by Shimanskiy (1968) as Ordovician to Lower Permian. Because of lack of detailed knowledge of the exact shape of the cross section, exact position of siphuncle, and structure of cameral deposits, the present specimen can be assigned to *Dolorthoceras* only with reservation. A closely similar genus, *Shikhanoceras* Shimanskiy (1954), is so far known only from rocks of Early Permian (Sakmarian and Artinskian) age and is distinguished from *Dolorthoceras* mainly by having a bulbous protoconch. Since this stage cannot be observed in the Ali Bashi specimen, no firm decision about its affinity to one genus or the other can be made. As far as we have been able to ascertain, no similar form has been reported from Upper Permian beds anywhere.

Occurrence. The figured specimen is from float at an undetermined locality and horizon; a second specimen, poorly preserved and unfigured, came from Loc. 2, 13.5 m above base of Ali Bashi Formation.

Repository. MCZ 9723 (Pl. 9, fig. 6). Unfigured specimen KU 73299.

Family and Superfamily uncertain

Genus *Neocycloceras* Flower and Caster, 1935

Type species, *Neocycloceras obliquum* Flower and Caster, 1935

Neocycloceras sp. indet.

Plate 9, figure 7

Remarks. In our collections, *Neocycloceras* is represented by five fragmentary specimens, all of them poorly preserved, ranging in length from 12 to 48 mm. With one exception the specimens are badly squashed, but in some fragments of phragmocones it can be seen quite clearly that the annulations are oblique with respect to sutures. The largest specimen (Pl. 9, fig. 7) is the adoral part of a phragmocone, 16 mm long, consisting of five fragmentary camerae, and an incomplete living chamber, 32 mm long. Although the specimen is distorted, it can be clearly seen that the annulations cross the sutures at a low angle.

All five specimens can be matched with specimens from the underlying Julfa beds that we have described as *Neocycloceras* cf. *N. obliqueannulatum* (Waagen) (Teichert and Kummel, 1973).

From the equivalents of the Ali Bashi Formation (lower "Induan") in the Armenian Dzhulfa area, Shimanskiy (*in* Ruzhentsev and Sarycheva, 1965) recorded six specimens of "*?Neocycloceras* sp." but did not illustrate any.

Occurrence. Loc. 3 at 2.10 m (KU 73295), 3 m (KU 73297, 73298), and 4.5 m (KU 73296) above base of Ali Bashi Formation, and in float (MCZ 9724).

Repository. MCZ 9724 (Pl. 9, fig. 7). Unfigured specimens KU 73295–73298.

Genus *Lopingoceras* Shimanskiy, *in* Ruzhentsev, 1962

Type species, *Lopingoceras lopingense* Shimanskiy *in* Ruzhentev, 1962.

For diagnosis and discussion of this genus see Teichert and Kummel (1973).

Lopingoceras sp.

Plate 9, figure 8

Remarks. In our collection the genus *Lopingoceras* is represented by six poorly preserved fragments of phragmocones, ranging in length from 10 to 24 mm. Although all specimens are squashed, it can be clearly seen that the annulations of the shell are straight and transverse, and in a few places it can be established that one annulation occurs per camera, situated between two sutures. The specimens are comparable to similarly poorly preserved specimens from the underlying Julfa beds that we have identified as *Lopingoceras lopingense* (Stoyanow) (Teichert and Kummel, 1973).

Shimanskiy (*in* Ruzhentsev and Sarycheva, 1965) did not list *Lopingoceras* from equivalents of the Ali Bashi Formation in the Armenian Dzhulfa area.

Occurrence. Loc. 2, 7.5 m; Loc. 3, 1.5

and 4.5 m above base of Ali Bashi Formation; Loc. 4, bed 3; and float.

Repository. MCZ 9779 (Pl. 9, fig. 8). Unfigured specimens MCZ 9750, KU 73300, 73301, 73302.

Order *NAUTILIDA* Agassiz, 1847

Superfamily TAINOCERATACEAE Hyatt, 1883

Family TAINOCERATIDAE Hyatt, 1883

Genus *Tainoceras* Hyatt, 1883

Type species, *Nautilus quadrangulus* McChesney, 1860

Tainoceras sp. indet.

Plate 9, figure 3

Discussion. A specimen consisting of half a volution of a phragmocone can readily be identified as an indeterminate species of the genus *Tainoceras.* The most characteristic features are the nodes on the ventral shoulders and the double row of nodes on the midline of the venter. *Nautilus dorsoplicatus* Abich (1878: 23) is clearly a species of the genus *Tainoceras.* The description and illustration of this species, however, are not sufficient for comparison with our specimen.

Shimanskiy (*in* Ruzhentsev and Sarycheva, 1965) records three specimens of *Tainoceras dorsoplicatum* (Abich) from the *Araxoceras* Zone, two specimens specifically indeterminate from the *Phisonites* Zone, and two specimens specifically indeterminate from the Ali Bashi Formation. Shimanskiy did not describe his specimens but illustrated some of them. The specimen he assigned to *Tainoceras* sp. 2 (ex. gr. *changlingpuense* Chao) is probably conspecific with the specimen recorded here.

Species of the genus *Tainoceras* are fairly common in mid-Pennsylvanian through Permian formations. The only Triassic form assigned to the genus is *Trematodiscus klipsteini* Mojsisovics (1882) from the Karnian of the Alps.

Occurrence. Float, Loc. 2, 4.5 m above base of Ali Bashi Formation.

Repository. MCZ 9721 (Pl. 9, fig. 3).

Genus *Metacoceras* Hyatt, 1883

Type species, *Nautilus (Discus) sangamonensis* Meek and Worthen, 1861

Metacoceras sp. indet.

Discussion. This genus is recognized from a fragmentary phragmocone representing a quarter volution of a conch. It has a broad, low, arched venter with prominent nodes on the ventral shoulders.

Shimanskiy (*in* Ruzhentsev and Sarycheva, 1965) recorded *Metacoceras dorsoarmatum* from the *Araxoceras* Zone of the Dzhulfian, and indeterminate forms from the *Vedioceras* and *Phisonites* zones.

Occurrence. Float from Ali Bashi Formation.

Repository. MCZ 9745.

Genus *Pleuronautilus* Mojsisovics, 1882

Type species, *Pleuronautilus trinodosus* Mojsisovics, 1902

The genus *Pleuronautilus* encompasses evolute nautiloids having dorsoventral and lateral whorl cross sections of approximately equal dimensions and with lateral ribs. The genus is quite common in Triassic formations and is represented by approximately 35 species. The type species is from Anisian strata in the Alps. A comprehensive review of the genus by Kummel (1953) demonstrated that it is almost equally common in Permian formations.

Shimanskiy (*in* Ruzhentsev and Sarycheva, 1965) recognized five species of *Pleuronautilus* from Dzhulfian strata plus two forms of uncertain specific identity. The great majority of the species and specimens came from the lowest Dzhulfian horizon, the *Araxoceras* Zone. The highest Permian horizon recognized by Ruzhentsev and Sarycheva (1965), the *Phisonites* Zone, yielded only one specimen, which Shimanskiy compared with *Pleuronautilus dieneri* Krafft, and two specimens that he questionably identified as *Pleuronautilus.* Their collections contained only one specimen from the lower "Induan" that Shimanskiy assigned with question to *Pleuronautilus.* Species of *Pleuronautilus* have, for the most part, been narrowly conceived, and this is especially true for those recognized from the Dzhulfa region. It needs to be emphasized also that the preservation of these specimens leaves much to be desired.

Pleuronautilus sp. indet.
Plate 9, figures 1, 2

Discussion. Two specimens are in our collection. One (Pl. 9, fig. 1) consists entirely of a body chamber with a whorl height of about 35 mm and a whorl width of about 42 mm. The lateral areas bear prominent radial ribs. The other specimen (Pl. 9, fig. 2) consists of a nearly complete volution of phragmocone. The adoral 2 cm appear to be part of the body chamber. The specimen has a diameter of 68 mm, a whorl height of 23 mm, a whorl width of 26 mm, and an umbilical diameter of 27 mm. No shell is preserved.

These specimens compare well with most of the previously described species from the Dzhulfa region. We suspect that at most probably no more than one or, possibly, two species are present in these faunas. Better collections are needed to properly appraise their affinities.

Occurrence. Loc. 1, bed 10, 5 m above base of formation (MCZ 9719), Loc. 4, bed 5 (MCZ 9720).

Repository. MCZ 9719 (Pl. 9, fig. 1), MCZ 9720 (Pl. 9, fig. 2).

Family KONINCKIOCERATIDAE Hyatt *in* Zittel, 1900

Genus *Temnocheilus* McCoy, 1844

Type species, *Nautilus (Temnocheilus) coronatus* McCoy, 1844

Temnocheilus sp. indet.
Plate 9, figures 4, 5

Discussion. A fragmentary phragmocone can be assigned to *Temnocheilus.* Its whorls are depressed, lateral areas convex, and they converge toward the dorsum. The ventral shoulders bear prominent nodes spaced about one cm apart. A small portion of an inner whorl, with a height of 12 mm, is preserved, and, in this, the whorl section is more rounded in cross section and the whorl sides only slightly convergent.

Kummel (1953) assigned to this genus 23 species of Pennsylvanian and Permian age. Our specimen is too incomplete for meaningful comparison with other recorded species. *Temnocheilus* was not recorded by Shimanskiy (*in* Ruzhentsev and Sarycheva, 1965) from any part of the section in Soviet Dzhulfa.

Occurrence. Loc. 3, float from 3 m above base of Ali Bashi Formation.

Repository. MCZ 9722 (Pl. 9, figs. 4, 5).

Superfamily TRIGONOCERATACEAE Hyatt, 1884

Family GRYPOCERATIDAE Hyatt *in* Zittel, 1900

Genus *Domatoceras* Hyatt, 1891

Type species, *Domatoceras umbilicatum* Hyatt, 1891

Domatoceras sp. indet.
Plate 8, figures 10, 11

Discussion. Our collections contain two fragmentary specimens that clearly belong to a species of *Domatoceras.* One specimen (Pl. 8, figs. 10, 11) is a phragmocone. The other consists of half a volution of a conch that appears to be mainly part of a body chamber.

Shimanskiy (*in* Ruzhentsev and Sarycheva, 1965) recorded five species from the *Araxoceras* Zone of Soviet Dzhulfa. In the overlying *Vedioceras* Zone, from which he had far fewer specimens, he records only two forms, not specifically identifiable. From equivalents of the Ali Bashi Formation, Shimanskiy had only one small and fragmentary specimen, which he named *Domatoceras* sp. 2 and which he figured (pl. 16, fig. 3) but did not describe. Published data are insufficient to establish whether it is conspecific with the specimens recorded here.

Occurrence. Float from Loc. 4, bed 3. Ali Bashi Formation.

Repository. MCZ 9718 (Pl. 8, figs. 10, 11), KU 73330.

Superfamily CLYDONAUTILACEAE Hyatt *in* Zittel, 1900

Family LIROCERATIDAE Miller and Youngquist, 1949

Genus *Liroceras* Teichert, 1940

Type species, *Coloceras liratum* Girty, 1911

Liroceras sp. indet.

Plate 8, figure 9

Discussion. Two specimens in our collections are readily assignable to *Liroceras*, whose principal features are the smooth, extremely involute, globular conch and simple sutures. Both specimens are somewhat deformed: one (Pl. 8, fig. 9) has a diameter of approximately 64 mm, the other, of about 95 mm. These specimens are too incomplete to allow a specific identification or meaningful comparison with other species of the genus. However, there is no question as to the generic assignment.

Shimanskiy (*in* Ruzhentsev and Sarycheva, 1965) did not record *Liroceras* from any part of the section near Soviet Dzhulfa.

Occurrence. Loc. 1, bed 1 (MCZ 9717), and float from Ali Bashi Formation (MCZ 9781).

Repository. MCZ 9717 (Pl. 8, fig. 9). Unfigured specimen MCZ 9781.

Genus *Paranautilus* Mojsisovics, 1902

Type species, *Nautilus simonyi* Hauer, 1850

Paranautilus sp. indet.

Plate 9, figures 9, 10

Discussion. A single specimen consisting of half a volution of a phragmocone belongs to *Paranautilus.* The conch is smooth, slightly compressed, and has a well-rounded venter.

Paranautilus ranges through the Permian and Triassic, but no Lower Triassic (Scythian)species are known. Shimanskiy (*in* Ruzhentsev and Sarycheva, 1965) listed five specimens of ?*Paranautilus* sp., as coming from horizons above the *Phisonites* Zone. However, he neither described nor illustrated them.

Occurrence. Specimen collected in place at Loc. 4, 1 m below the top of Ali Bashi Formation.

Repository. MCZ 9727 (Pl. 9, figs. 9, 10).

Subclass **AMMONOIDEA** Agassiz, 1847

Family PARAGASTRIOCERATIDAE Ruzhentsev, 1951

Genus *Pseudogastrioceras* Spath, 1930

Type species, *Goniatites abichianus* von Möller (as figured *in* Arthaber, 1900, pl. 18, figs. 5a–d)

Pseudogastrioceras abichianum (von Möller)

Plate 4, figures 2–4; Text-figures 11A, B

Goniatites striatus Martin, –Abich, 1878: 9, pl. 1, figs. 1, 1a, 2, 2a, 3; pl. 2, figs. 2, 2a.

Goniatites Abichianus von Möller, 1879: 239.

Gastrioceras Abichianum, –Karpinsky, 1890: 89; Arthaber, *in* Frech and Arthaber, 1900: 219, pl. 18, figs. 5a–d; Stoyanow, 1910: 103, 105; Diener, 1921: 14.

Pseudogastrioceras abichianum, Spath, 1930: 8; Miller and Furnish, 1940: 91; Miller *in* King *et al.*, 1944: 88; Glenister and Furnish, 1961: 718; Ruzhentsev and Sarycheva, 1965, pl. 17, fig. 2; Furnish, 1966: 279; Taraz, 1969: 691.

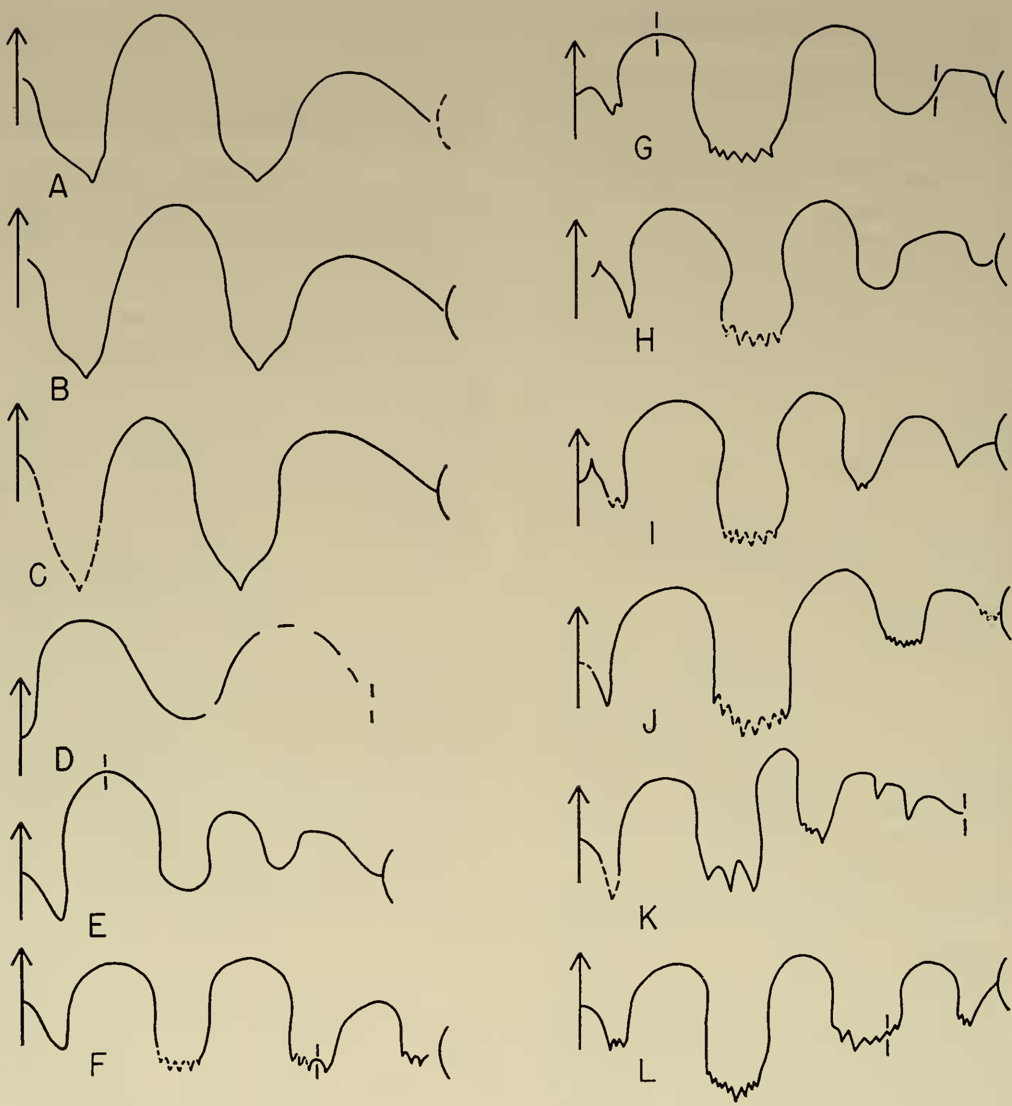
Discussion. Our collections from the Ali Bashi Formation have yielded 12, mostly fragmentary, specimens of *Pseudogastrioceras* from float. The stratigraphically highest specimen comes from a bed 7.5 m above the base of the formation.

Measurements (in millimeters) of three of the most completely preserved specimens are as follows:

	Diameter	*Width*	*Whorl height*	*Umbilical diameter*
Pl. 4, fig. 2	73.0?	?	39.0?	8.5?
Pl. 4, figs. 3, 4	33.8	11.5?	19.6	4.5?
MCZ 9710	21.1	9.1	13.5	1.8

The largest specimen in the collection is a fragment of a phragmocone from which it can be estimated that the complete specimen had a diameter of at least 100 mm. This specimen shows the striations well preserved in the ventral region. The sutures of two of our specimens are shown in Text–figures 11A, B.

The genus *Pseudogastrioceras* has been exhaustively discussed by Miller and Furnish (1940), Miller (*in* King et al., 1944), Glenister and Furnish (1961), and Furnish



Text-figure 11. Diagrammatic representation of the suture of ammonoids, all from the Ali Bashi Formation, except D. A, *Pseudogastrioceras abichianum* (von Möller) at a diameter of approximately 25 mm, MCZ 9692; B, *Pseudogastrioceras abichianum*, at a diameter of approximately 18 mm, MCZ 9744; C, *Strigogoniatites* sp. indet., at a diameter of 26 mm, MCZ 9695; D, *Neoaganides* n. sp., from Dzhulfian beds, at a diameter of 20 mm, MCZ 9782; E, *"Pleuronodoceras"* sp. indet., at a diameter 26 mm, MCZ 9693; F, *Phisonites triangulus* Shevyrev, at a whorl height of 17 mm, MCZ 9711; G, *Xenodiscus dorashamensis* Shevyrev, at a whorl height of 6 mm, MCZ 9687; H, *Iranites transcaucasius*, at a diameter of 20 mm, MCZ 9670; I, *Shevyrevites shevyrevi* n.g., n. sp., at a diameter of 23 mm, MCZ 9680; J, *Shevyrevites shevyrevi* n.g., n.sp., at a whorl height of 11 mm, MCZ 9679; K, *Urartoceras* sp. indet., at a diameter of 25 mm, MCZ 9683; L, *Phisonites triangulus* Shevyrev, at a whorl height of 21 mm, MCZ 9712.

(1966). It is widely distributed in Permian strata throughout most of the world. The specimens in our collections add nothing to the understanding of the morphology of *P. abichianum*, but the numbers of specimens clearly show that the species is more abundant in the Ali Bashi Formation than was previously believed.

Pseudogastrioceras is extremely well represented in the Julfa beds. In the Dzhulfa sections studied by Ruzhentsev and Sarycheva (1965), this species is by far the most common one in the *Araxoceras* Zone. It is likewise predominant, but less so, in the overlying *Vedioceras* Zone; and it is the second most common species in the *Phisonites* Zone. Above this, Ruzhentsev and Shevyrev (*in* Ruzhentsev and Sarycheva, 1965) recorded only a single specimen from the *Bernhardites* Zone.

Occurrence. Ali Bashi Formation, Loc. 2, 90 cm and 4.5 m above base and Loc. 3, 4.5 m and 7.5 m above base (MCZ 9698); Loc. 4, float (MCZ 9692); Loc. 4, KU 73311–73314; float, no locality (MCZ 9691, 9744).

Repository. MCZ 9691 (Pl. 4, fig. 2), MCZ 9692 (Pl. 4, figs. 3, 4), suture specimens MCZ 9744, 9692 (Text–figs. 11A, B). Unfigured specimens MCZ 9698, KU 73311–73314.

Genus *Strigogoniatites* Spath, 1934
[= *Grabauites* Sun, 1947]

Type species, *Glyphioceras angulatum* Haniel, 1915: 51, text-figs. 11, 12

Strigogoniatites sp. indet.
Plate 4, figures 9–12; Text-figure 11c

Discussion. Three specimens are definitely assignable to *Strigogoniatites* but are not sufficiently complete to allow specific determination. One of them (Pl. 4, fig. 9) is a portion of phragmocone. The whorl is compressed, having converging flanks and an acutely rounded venter. Between the venter and the beginning of the first lateral saddle is a series of narrow strigations, the exact number of which cannot be determined because of poor preservation. Another specimen (Pl. 4, fig. 12) is a fragment similarly preserved but consisting of body chamber only, as no suture is visible. The whole section, venter, and strigations are like those of the first-mentioned specimen.

The third specimen is a fairly well-preserved phragmocone of 27 mm diameter. The adoral whorl has a width of 9.1 mm, a height of 16.6 mm, and an umbilical diameter of 1.5 mm. Its whorl section is compressed with flanks that converge markedly to form an acute venter. The umbilical shoulders are sharply rounded and the umbilical walls steep. Six narrow strigations are seen between the venter and approximately the mid-part of the first lateral lobe. The suture is shown in Text–figure 11C.

Strigogoniatites appears to be a rare form that ranges through much of the Permian. Most authors who have studied this genus have emphaszed its gradational character to *Pseudogastrioceras.* Only six species have been assigned to it. The type species, *Glyphioceras angulatum* Haniel (1915), is from an unknown horizon and locality in Timor. Haniel (1915: 51) thought it probably came from Noil Boewan, Timor. Smith (1927: 28) and Spath (1934: 15) expressed the opinion that the specimen was probably Early Permian in age. Miller and Furnish (1940: 94) were inclined to assign a Late (?) Permian age to the specimen because the Noil Boewan region has yielded a Basleo fauna, and their American species, *Strigogoniatites fountaini*, occurs in the Upper Permian Lamar Limestone of Texas.

Chao (1965) has listed two species of *Strigogoniatites* of Early Permian age from the "Kufeng" siliceous shale in the Liukiang district, Kwangsi, China. One of these, S. *liuchowensis* (*nom. nud.*), has a more inflated conch than the forms described here, and the acute venter does not appear until the conch reaches a diameter of approximately 40 mm. The other species, S. *nodosus* (*nom. nud.*), is very similar except for part of the ornamentation. *Gastrioceras* (*Girtyites*) *liui* Grabau (1924: 478) from the Paoan shale of Hupeh, China, is most probably a representative of *Strigogoniatites* (Spath, 1934: 15). This species, based on a crushed specimen, was made the type of the genus *Grabauites* by Sun (1947).

The North American species, *Strigogoniatites fountaini*, from the Lamar Limestone of West Texas was based on three incomplete specimens (Miller and Furnish, 1940). One of them, with a diameter of 28 mm, has a rounded venter. A fragment of a phragmocone, very similar to the specimens here illustrated (Pl. 4, figs. 9, 12), is part of a specimen that probably was at least 100 mm in diameter. In this specimen the venter is described as subangular. *Strigogoniatites kingi* Miller (*in* King *et al.*, 1944: 92) is a more inflated form, in which angularity of the venter does not appear until a diameter of approximately 40 mm. In addition, strigations entirely cover the lateral areas.

It needs to be emphasized that the six known species of *Strigogoniatites* have been established on the basis of very few specimens; in fact, three of the species were established on the basis of a single specimen each. As far as one may judge from available data, angularity of the venter develops at a progressively earlier stage through Permian time. The small complete specimen recorded here (Pl. 4, figs. 10, 11) has an angular venter at a diameter of 18 mm. This is the smallest diameter at which the appearance of this feature has been noted so far.

Shimanskiy (*in* Ruzhentsev and Sarycheva, 1965) did not record *Strigogoniatites* from anywhere in the Soviet Dzhulfa area.

Occurrence. Float from Ali Bashi Formation; specimen of Plate 4, figure 9, from Loc. 2, 2.1 m above base; that of Plate 4, figure 12, from Loc. 3, 4.5 m above base; and that of Plate 4, figures 10, 11, from Loc. 1, 3.5 m above base of the formation.

Repository. MCZ 9694 (Pl. 4, fig. 9), MCZ 9695 (Pl. 4, figs. 10, 11), MCZ 9696 (Pl. 4, fig. 12).

Family Popanoceratidae Hyatt, 1900

Genus *Propopanoceras* Tumanskaya, 1938

Type species, *Popanoceras lahuseni* Karpinsky, 1889: 67, pl. 5, figs. 1–3

?Propopanoceras sp. indet.

Plate 4, figure 1

Discussion. Our collections contain a crushed specimen in which no trace of a suture is preserved. The undistorted shell was involute with a compressed whorl section and a rounded venter. The greater part of the outer half of the whorl sides bears prominent ribs that increase in size toward the ventral shoulders.

This specimen is quite similar to *Propopanoceras kweichowense* Chao (*nom. nud.*, 1965) from the Chihsia Formation (Waitoushen shale), east of Maokou, Linchi district, Kweichow Province, China, and is considered to be of Lower Permian age. The only other species of this genus are from strata of Sakmarian age on the western slope of the Urals (Chao, 1965).

Shimanskiy (*in* Ruzhentsev and Sarycheva, 1965) did not record *Propopanoceras* from the Soviet Dzhulfa area.

Occurrence. Loc. 4, float from undetermined horizon in Ali Bashi Formation.

Repository. MCZ 9690 (Pl. 4, fig. 1).

Family PSEUDOHALORITIDAE Ruzhentsev, 1957

Genus *Neoaganides* Plummer and Scott, 1937

Type species, *N. grahamensis* Plummer and Scott, 1937: 350, pl. 40, figs. 4–9; text-fig. 72

Neoaganides n. sp.

Plate, 4, figures, 5, 6; Text-figure 11D

Discussion. We are indebted for the generic identification of this form to W.M. Furnish and B.F. Glenister of the University of Iowa. The single small specimen available is tightly involute, slightly compressed, and smooth. The ammonoids we collected from the underlying Dzhulfian strata are being studied by Furnish and Glenister. This collection contains a specimen of somewhat larger dimensions that will be described as a new species of *Neoaganides*. In addition, Furnish and Glenister believe the small specimen recorded here is conspecific with the Dzhulfian specimen. Our specimen does not lend itself to the drawing of a suture but that of the Dzhulfian specimen is shown in Text–figure 11D.

It now appears that this genus is very long ranging and of wide geographic extent. It is very common in Upper Pennsylvanian strata of Kansas, Oklahoma, and Texas. Furnish and Glenister (personal communication) have in preparation a study on the Permian representatives of this genus. They advise us that they have specimens from West Texas, Sicily, Arabia, the Alborz Mountains of Iran, and Hunan in China. In addition they have our specimen from the Julfa beds of northwest Iran. In regard to the stratigraphic implication of *Neoaganides*, Furnish and Glenister (written communication, letter of February, 1970) wrote us as follows: "The forms with simple suture, *Neoaganides*, are regarded as secondarily primitive. They have no value of exact age determination and are not even specifically identifiable unless most characters can be observed."

Occurrence. Float from approximately middle of Ali Bashi Formation.

Repository. MCZ 9692 (Pl. 4, figs. 5, 6).

Family "PLEURONODOCERATIDAE" Chao, 1965 (*nom. nud.*)

Genus "*Pleuronodoceras*"[1] Chao, 1965 (*nom. nud.*)

Illustrated specimen, "*Pleuronodoceras dushanense*" Chao, 1965, text-fig. 3d, pl. 2, figs. 23, 24 (*nom. nud.*)

"*Pleuronodoceras*" sp. indet.

Plate 4, figures 7, 8; Text-figure 11E

Discussion. A single specimen in an imperfect state of preservation can be assigned to "*Pleuronodoceras.*" It has a diameter of 30.5 mm, a whorl width of 8.9 mm, a height of 11.7 mm, and an umbilical diameter of 11.3 mm. The whorls are subquadrate in cross section, flanks flattened, converging very slightly toward the venter. The umbilical and ventral shoulders are rounded and the venter is marked by a prominent keel. The lateral areas of the whorls have slightly forward-projecting ribs that curve more distinctly forward on the ventral shoulder. The adoral half of the last volution has ten such ribs. The suture is illustrated on Text–figure 11E. The absence of denticulations of the lobes is believed to be entirely due to weathering.

The only specimen previously assigned to "*Pleuronodoceras*" is "*P. dushanense*" Chao (1965, pl. 2, figs. 23, 24) from the Changhsing limestone, Tushan, Kwangteh District, Anhwei Province, China. The illustrated specimen is approximately twice the size of the specimen recorded here, but in all other morphological features such as whorl shape, size of umbilicus, ornamentation, the Ali Bashi specimen appears to be identical with it. The sutures are likewise very similar.

Chao (1965) recorded this genus from a number of localities in eastern China where it is associated with *Pseudogastrioceras*, "*Pseudotirolites*," "*Pachydiscoceras*," and other ammonoid genera, and occurs at a horizon regarded by him as youngest Permian.

Shimanskiy (*in* Ruzhentsev and Sarycheva, 1965) did not record similar forms from the Soviet Dzhulfa area.

Occurrence. Float from undetermined horizon in Ali Bashi Formation.

Repository. MCZ 9693 (Pl. 4, figs. 7, 8).

Family "PSEUDOTIROLITIDAE" Chao, 1965 (*nom. nud.*)

Genus "*Pseudotirolites*" Chao, 1965 (*nom. nud.*)

Illustrated specimen, "*Pseudotirolites orientalis*" Chao, 1965, pl. 2, figs. 12, 13 (*nom. nud.*)

"*Pseudotirolites*" sp. indet.

Plate 5, figures 16–19

Discussion. Two fragmentary specimens, each consisting of half a volution of a body chamber, appear to belong to this genus. The whorls are depressed and have a broad venter marked by an acute crest. The lateral areas bear prominent ribs that increase in size toward the ventral shoulders and are slightly projected forward.

[1] In an important paper published in 1965, Chao Kingkoo created a number of new names for what were intended to be new taxa on the family, genus, and species level. Although these new forms were well illustrated, they were not formally described and their names are therefore to be regarded as *nomina nuda*. Our use of them here for purposes of morphological comparisons is not to be construed as an attempt to validate these names.

Chao (1965) illustrated two "species" of his new genus; both come from the Talung Formation of China from his youngest Permian horizon. The associated fauna contains *Stacheoceras, Pseudogastrioceras, "Pleuronodoceras," "Pseudostephanites,"* and other genera. No similar forms seem to be known in the Soviet Dzhulfa area.

Occurrence. Float from undetermined horizon in Ali Bashi Formation. Loc. 2 (MCZ 9710), Loc. 4 (MCZ 9709).

Repository. MCZ 9709 (Pl. 5, figs. 16, 17), MCZ 9710 (Pl. 5, figs. 18, 19).

Genus *"Pseudostephanites"* Chao, 1965 (*nom. nud.*)

Illustrated specimen, *"Pseudostephanites costatus"* Chao, 1965, pl. 2, figs. 14–16 (*nom. nud.*)

"Pseudostephanites" sp. indet.
Plate 4, figure 13

Discussion. A single, small, incomplete specimen can be assigned to *"Pseudostephanites."* The whorls are depressed and have a broadly rounded venter. The rounded lateral areas bear large nodes or ribs that occupy the whole area. The specimen has an approximate diameter of 25 mm with an umbilical width of 9 mm. The sutures are not preserved.

The distinctive large lateral ribs are the primary basis for the taxonomic assignment of this specimen. The specimen of *"Pseudostephanites"* illustrated by Chao is from the Talung Formation, Chaotian, Kwangyywan District, Szechwan Province, China, where it is found in association with *Stacheoceras, Pseudogastrioceras, "Pseudotirolites," "Tapashanites," "Pleuronodoceras,"* and other genera. This assemblage characterizes the youngest Permian horizon recognized by Chao (1965) in South China.

Occurrence. Float from undetermined horizon in Ali Bashi Formation.

Repository. MCZ 9697 (Pl. 4, fig. 13).

Family XENODISCIDAE Frech, 1902

Genus *Phisonites* Shevyrev *in* Ruzhentsev and Sarycheva, 1965

Type species, *Phisonites triangulus* Shevyrev *in* Ruzhentsev and Sarycheva, 1965

Phisonites triangulus Shevyrev
Plate 8, figures 1–8; Text-figure 11L

Phisonites triangulus Shevyrev *in* Ruzhentsev and Sarycheva, 1965: 168–169, pl. 21, figs. 4, 5.

Discussion. Our collections contain 20 specimens of *Phisonites triangulus* of which most are fragments, and many are crushed. Shevyrev states that his own collections from Soviet Dzhulfa contained only 12 specimens from a single locality (Dorasham 2) and that these also were mainly fragments. The new material from Kuh-e-Ali Bashi does add, however, to our knowledge of this unusual ammonoid.

The smallest specimen in this collection has a diameter of 32 mm and the flared umbilical shoulder is quite prominent, but the whorl cross section is not as markedly triangular as it is in later growth stages (Pl. 8, fig. 5). The inner whorls are not preserved in any of our specimens, and the same appears to be true of Shevyrev's specimens. The largest specimen in our collection has a diameter of approximately 90 mm; its suture is shown in Text–figure 11L.

Occurrence. Float from lowest part of Ali Bashi Formation.

Repository. MCZ 9711 (Pl. 8, figs. 1, 2), MCZ 9712 (Pl. 8, figs. 3, 4), MCZ 9713 (Pl. 8, fig. 5), MCZ 9714 (Pl. 8, fig. 6), MCZ 9715 (Pl. 8, figs. 7, 8), unfigured specimens MCZ 9716, KU 73365–73380.

Genus *Xenodiscus* Waagen, 1879
[= *Xenaspis* Waagen, 1895]

Type species, *Xenodiscus plicatus* Waagen, 1879: 34, pl. 2, fig. 1

Xenodiscus dorashamensis Shevyrev
Plate 3, figures 9–17; Text-figure 11G

Xenodiscus dorashamensis Shevyrev *in* Ruzhentsev and Sarycheva, 1965: 166, pl. 21, figs. 2, 3.

Xenaspis araxensis Shevyrev *in* Ruzhentsev and Sarycheva, 1965: 166, pl. 21, fig. 1.

Discussion. Our collections contain 12 specimens of *Xenodiscus dorashamensis* in a moderately good to poor state of preservation. The largest specimen has a diameter of 49 mm, the smallest a diameter of 18.5 mm. Some of the specimens are essentially smooth, except for traces of growth lines; others have radial ribs. There is much variation in the prominence of the ribs. The morphology of our specimens is identical with that described and illustrated by Shevyrev. The suture of one specimen is illustrated in Text–figure 11G.

No general consensus exists as to whether *Xenodiscus* and *Xenaspis* are synonyms. The type species of *Xenodiscus* is *X. plicatus* Waagen (1879), that of *Xenaspis* Waagen (1895) is *Ceratites carbonarius* Waagen (1872), both from the Chhidru Formation of the Salt Range. These two genera were differentiated on the basis of ornamentation, *plicatus* having radial ribs, *carbonarius* being essentially smooth. Waagen had only one specimen of *X. plicatus* and four of *X. carbonarius*, none of which is well preserved, a fact not noticeable in the fine line drawings Waagen reproduced in his monograph. Photographs of these specimens have been published by Kummel (1970) and illustrations of topotype specimens were reproduced by Schindewolf (1954). Schindewolf (1954) presented convincing arguments for placing *Xenaspis* in synonymy of *Xenodiscus*, and this is the procedure followed here, as it was by Teichert (1966) and Kummel (1970). At the same time, Furnish (1966), following "convention," retained both genera, as did Shevyrev (*in* Ruzhentsev and Sarycheva, 1965).

Occurrence. Float from Ali Bashi Formation, all specimens collected from within 1.5 m of the base of the Formation.

Repository. MCZ 9684 (Pl. 3, figs. 9, 10), MCZ 9685 (Pl. 3, figs. 11, 12), MCZ 9686 (Pl. 3, figs. 13, 14), MCZ 9687 (Pl. 3, fig. 15), MCZ 9688 (Pl. 3, figs. 16, 17), unfigured specimens MCZ 9689, KU 73331–73334.

Genus *Iranites* Teichert and Kummel n. gen.
Type species, *Tompophiceras transcaucasium* Shevyrev *in* Ruzhentsev and Sarycheva, 1965: 169, pl. 21, fig. 6.

One of the more common ammonoids in the Ali Bashi Formation is an evolute ceratite with a narrowly rounded to acute venter and a variable pattern of radial ribs on the flanks. Shevyrev (*in* Ruzhentsev and Sarycheva, 1965) assigned these forms to the genus *Tompophiceras* Popov (1961). The type species of *Tompophiceras, T. fastigatum* Popov, is based on a single, incomplete specimen from the *Otoceras* Zone of the eastern Verkhoyansk region, eastern Siberia. Popov (1961) emphasized that the sharpening of the venter is confined to the outer volution and that the inner whorls are rounded. Tozer, on the basis of personal examination of the type specimen, recently came to the conclusion that "The venter of the only known specimen is not well preserved. Examination of this specimen left me unconvinced that it was truly fastigate" (Tozer, 1969: 353). On the appearance of the above statement we questioned our friend Yu. N. Popov about the holotype of *Tompophiceras fastigatum* and he reaffirmed his original observation (letter to Kummel, 27 January 1970). In addition, Popov emphasized that, as he had stated in the original description of the species (Popov, 1961: 27), it was only the outer volution in which the venter was fastigate and that the inner volutions had rounded venters. Subsequently, Kummel, in June, 1970, has had the opportunity to examine this specimen and agrees completely with Popov's interpretation.

Shevyrev (*in* Ruzhentsev and Sarycheva, 1965) assigned eight specimens from Dorasham 2 to *Tompophiceras transcaucasium*. One would judge that all are fragmentary since the only specimen illustrated consists of only one-third of a volution of a conch. Tozer (1969: 353) stated that the specimen is crushed and the "fastigation apparent." Shevyrev differentiated *T. transcaucasium* from *T. fastigatum* entirely on the basis of minor differences in the suture. The smallness of the samples and rather indifferent preservation has made interpretation of these two species of *Tompophiceras* difficult. In addition to the eight specimens of *T. transcaucasium*, Shevyrev recorded 37 specimens of the genus which he left indeterminate. All specimens came from the *Tompophiceras* Zone, the lowest "Induan" in Shevyrev's terminology.

Our collections have yielded a large number of specimens that help to clarify the nature of this taxon. First it needs to be emphasized that whether or not Shevyrev's type specimen is crushed as stated by Tozer (1969: 353), one of the common ammonoids of the Ali Bashi Formation near Julfa is an evolute form with a narrow to acute rounding of the venter. The smallest nondeformed specimen in our collection has an acute venter at a diameter of 13 mm. This feature may appear earlier, but this cannot be determined from the material available. The true and most significant difference between *Tompophiceras fastigatum* Popov and *Tompophiceras transcaucasium* Shevyrev is in the time of appearance of the acute rounding of the venter. In the Siberian species fastigation appears only in the outer volution and in the species from the Ali Bashi Formation it appears at a very early growth stage. It is clear from this difference that these two species are not congeneric and thus we introduce the generic name *Iranites* for the taxon in the Ali Bashi Formation. Fastigation of the venter occurred repeatedly in various lineages of Late Permian and Early Triassic ammonoids. In most cases it can be established that such forms are offshoots of forms with rounded venters and rarely are ancestral to other lineages.

Iranites transcaucasius (Shevyrev)
Plate 5, figures 1–15; Text-figure 11H

Tompophiceras transcaucasium Shevyrev *in* Ruzhentsev and Sarycheva, 1965: 169, pl. 21, fig. 6; Shevyrev, 1968: 85, pl. 1, fig. 6.

Discussion. Our collections contain 53 specimens of *Iranites transcaucasius*, the great majority being fragments of body chambers. The main features of the conch are the acutely rounded to angular venter, the ovoid whorl section, and the lateral ribs. It is quite apparent that the rib pattern varies considerably, as demonstrated by the specimens illustrated on Plate 5, figures 1–15. The best-preserved and undeformed specimen is that shown on Plate 5, figures 1–3. This is a phragmocone of 22 mm diameter that clearly shows sharpening of the venter down to a diameter of 13 mm. At smaller diameters the venter cannot be seen. The suture (Text–figure 11H) has two ceratitic lateral lobes; the serrations of the second lateral lobe are minute.

A number of Late Permian and Early Triassic ammonoid genera with narrowly rounded to acute venters are known. *Xenodiscites* Miller and Furnish (1940), known from the Upper Permian of Mexico and Texas, is a more involute form having radial ribs confined entirely to the earliest whorls and a more simplified suture. A closely related genus, *Cibolites* Plummer and Scott (1937), is more compressed and smooth, and has a suture with two goniatitic lateral lobes. *Cibolites* has the same geographic and stratigraphic distributions as *Xenodiscites.* In the Lower Triassic (Scythian) there are many more genera of ammonoids with narrowly rounded to acute venters. In the lowest Scythian zone, that of *Otoceras* and *Ophiceras*, only *Tompophiceras* has such a venter, and it is developed only on the outer volution. At a slightly higher horizon *Vishnuites* Diener (1897) and *Subinyoites* Spath (1930) make their appearance, but their shells are much more involute and quite unlike *Iranites.* In the mid-Scythian we find such forms as *Subvishnuites* Spath (1930), *Preflorianites* Spath (1930), and *Inyoites* Hyatt and Smith (1905), but each of these genera is quite distinct from *Iranites.*

Most of the Upper Permian and Lower Triassic genera mentioned above are known from few species and specimens. This fact, combined with the relatively simple nature of the conch, makes comparison very difficult. There is nothing inherent in the morphology of *Iranites transcaucasius* to suggest a precise age assignment except that it may be anywhere from Late Permian through Early Triassic.

Occurrence. Loc. 1, bed 10 (MCZ 9701), Loc. 2 (MCZ 9704, 9705, 9706, 9707, 9708), Loc. 3 (MCZ 9699, 9700), float from Ali Bashi Formation. The stratigraphically highest specimen was found 10.5 m above the base of the formation.

Repository. MCZ 9699 (Pl. 5, figs. 1–3), MCZ 9700 (Pl. 5, figs. 4, 5), MCZ 9701 (Pl. 5, figs. 6, 7), MCZ 9702 (Pl. 5, fig. 8), MCZ 9703 (Pl. 5, fig. 9), MCZ 9704 (Pl. 5, fig. 10), MCZ 9705 (Pl. 5, fig. 11), MCZ 9706 (Pl. 5, figs. 12, 13), MCZ 9707 (Pl. 5, figs. 14, 15), unfigured specimens MCZ 9708, KU 73342–73364.

Genus *Shevyrevites* Teichert and Kummel, n. gen.

Type species, *Shevyrevites shevyrevi* Teichert and Kummel, n. sp.

The ammonoid fauna of the Ali Bashi Formation includes evolute shells having a subrectangular whorl section, radial ribs, and a simple two-lobed ceratitic suture. These forms we regard as congeneric with forms that Shevyrev (*in* Ruzhentsev and Sarycheva, 1965) described as *Bernhardites radiosus* and *B. nodosus,* but we believe that the generic assignments were incorrect. Shevyrev (*in* Ruzhentsev and Sarycheva, 1965) introduced the new genus *Bernhardites* (type species *Celtites radiosus* Koken *in* Frech, 1905), stated to be from the Lower Ceratite limestone at Chhidru in the Salt Range. He included in this new genus *Celtites fortis* Koken (*in* Frech, 1905) from the Lower Ceratite limestone of the Salt Range in West Pakistan and described a new species, *Bernhardites nodosus,* from the equivalents of the Ali Bashi Formation in the Dzhulfa region. Shevyrev's collections contain 29 specimens that he identified as *B. radiosus* and only two of *B. nodosus.*

Ammonoids with evolute shells having somewhat compressed, subquadrate whorl sections, a low rounded venter, lateral ribs, and a simple suture with two denticulated lateral lobes were common in Late Permian and Scythian times. The genus *Bernhardites* is such a form. Ammonoids of this general morphology are very difficult to identify and their phylogenetic relationships are not at all well known. Is the whole complex of such forms the product of a complex iterative pattern of evolution or are the many genera of the "form" no more than parts of a single, linear evolutionary series? The range of intraspecific variation for most of the many species and genera in this group of ammonoids is poorly known. One can be sure of their identification only when they are associated with a fairly large and distinctive fauna from which an age can be deduced with a fair amount of certainty.

Noetling (*in* Frech, 1905: 164) listed *Celtites radiosus* from the Lower Ceratite limestone and in fact named what he believed to be the lowest zone of the Salt Range Triassic sequence after this species, designating the Lower Ceratite limestone as the content of that zone. The Lower Ceratite limestone of Waagen (1895) is the basal unit of the Mittiwali Member of the Mianwali Formation (Kummel, 1966). In 1961–62, during approximately four months of field work studying the Triassic formations of the Salt Range and Surghar Range, Kummel did not once encounter this species in the Lower Ceratite limestone. He found, however, that it occurs in fair abundance in the overlying Ceratite marl of Waagen (1895). In addition, several specimens collected and identified by Koken were available for study. Matrix on some of the specimens in the Koken collection also suggests that they came from the Ceratite marl and not from the Lower Ceratite limestone. The many specimens in Kummels' collections show considerable variation in whorl width and rib pattern. The lateral ribs vary from narrow and rather delicate to broad and blunt. Likewise the whorl section varies from slightly compressed to a shape in which width and height are approximately equal. *Celtites* *fallax* Noetling, (*in* Frech, 1905, pl. 22, fig. 5) falls well within the range of intraspecific variation observed in *Celtites radiosus.* Frech (1905: 164) distinguished the middle part of the Ceratite marl as the *Celtites fallax* Zone. The sequence of zones for the Lower Triassic formation of the Salt Range established by Noetling is in need of complete revision. Restudy of the ammonoid faunas by Kummel is now in progress.

The specimens of "*Bernhardites*" from the Ali Bashi Formation have slightly compressed whorl sections with ribs on the lateral areas that extend and expand from the umbilical shoulder to the ventral shoulder. The maximum width of the ribs is at the ventral shoulder. This is not the rib pattern of *Celtites radiosus* or *Celtites fallax.* In these species the ribs expand very slightly from the umbilical shoulder to the ventral shoulder, but terminate before reaching the ventral shoulder. It is primarily on the basis of these features that the species from the Ali Bashi Formation is considered not to be congeneric with the Salt Range species. Thus a new generic and a new specific name, *Shevyrevites shevyrevi,* is here proposed.

Shevyrevites shevyrevi Teichert and Kummel, n. sp.

Plate 3, figures 1–6; Text-figures 11I, K

Bernhardites radiosus Shevyrev (non *Celtites radiosus* Koken, *in* Frech, 1905) *in* Ruzhentsev and Sarycheva, 1965: 171, pl. 21, fig. 7; Shevyrev, 1968: 86, pl. 1, fig. 7; pl. 2, fig. 1; Taraz, 1969: 691.

Bernhardites nodosus Shevyrev, *in* Ruzhentsev and Sarycheva, 1965: 171, pl. 21, fig. 7; Shevyrev, 1968: 87, pl. 2, fig. 2; Taraz, 1969: 691.

Description. Evolute, with slightly compressed whorl section that bears lateral ribs with maximum prominence at the ventral shoulder; venter rounded. Suture simple with two denticulated lateral lobes and partial auxiliary on umbilical seam.

Discussion. Our collections contain 16 specimens, mainly fragments, of rather indifferent preservation. Though our material is fragmentary it is quite apparent that considerable variation in rib spacing and expression exists. The range of variation is shown by the specimens illustrated on Plate 3. "*Bernhardites*" *nodosus* was differentiated by Shevyrev on the basis of inflated ribs on the inner whorls. Shevyrev had only two specimens of this species. Their rib pattern is believed to fall well within the variation range of that of *S. shevyrevi.*

Occurrence. Loc. 1 (MCZ 9678), Loc. 2 (MCZ 9681, 9682), Loc. 3 (MCZ 9679), float from Ali Bashi Formation (MCZ 9680). The stratigraphically highest specimens were collected 10.5 m above base of the formation.

Repository. Holotype, MCZ 9678 (Pl. 3, figs. 1, 2); paratypes, MCZ 9679 (Pl. 3, fig. 3), MCZ 9680 (Pl. 3, figs. 4, 5), MCZ 9681 (Pl. 3, fig. 6), unfigured specimens MCZ 9682, KU 73335–73341.

Family *Araxoceratidae* Ruzhentsev, 1959

Genus *Urartoceras* Ruzhentsev, 1959

Type species, *Urartoceras abichianum* Ruzhentsev, 1959: 64, figs. 1G, 2G

Urartoceras sp. indet.

Plate 3, figures 7, 8; Text-figure 11K

Discussion. We are indebted to W. M. Furnish and B. F. Glenister for advice on the identification of a single, somewhat poorly preserved specimen that can be assigned to *Urartoceras.* It has a diameter of 28 mm and is crushed, and one side is very badly weathered. The venter is fastigate, the lateral areas concave, and the umbilical region flared. The umbilicus is distorted by crushing and has a diameter of approximately 3.5 mm. The suture is shown in Text–figure 11K.

The araxoceratids were first recognized from the Dzhulfian strata of Soviet Dzhulfa. They are a highly complex and variable group of ammonoids in need of much taxonomic clarification (Furnish and Glenister, written communication to Kummel). Our specimen most closely resembles *Urartoceras.* This genus is monotypic and the type species was established on the basis of two specimens from the *Vedioceras* Zone of the

Soviet Dzhulfian Stage (Ruzhentsev and Sarycheva, 1965: 48). The suture of our specimen is almost identical with that of the type species.

Occurrence. Ali Bashi Formation, Loc. 4, bed 3, 3 m above base of formation.

Repository. MCZ 9683 (Pl. 3, figs. 7, 8).

Family DZHULFITIDAE Shevyrev, 1965

Genus *Paratirolites* Stoyanow, 1910

[= *Dzhulfites, Abichites* Shevyrev *in* Ruzhentsev and Sarycheva, 1965]

Type species, *P. kittli Stoyanow,* 1910

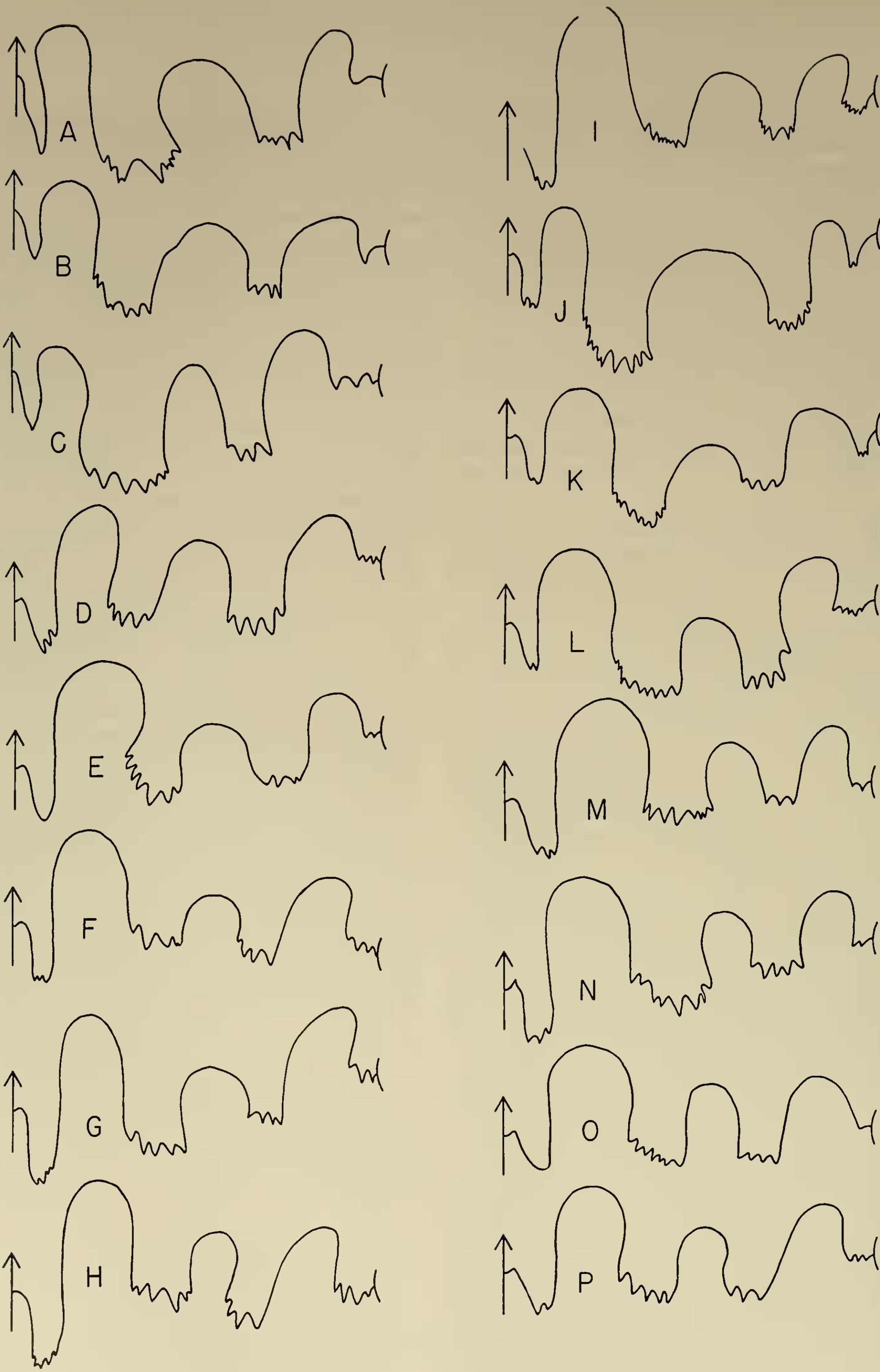
The most characteristic and common ammonoids of the Ali Bashi Formation are members of the genus *Paratirolites.* From the *Tompophiceras, Dzhulfites, Bernhardites,* and *Paratirolites* beds, as recognized in the Soviet Dzhulfa region by Ruzhentsev and Sarycheva (1965), Shevyrev had available for study a total of 181 specimens of ammonoids from this group of which 116 belong to the family Dzhulfitidae divided among three genera and ten species. They are indeed a peculiar and most interesting group of ammonites. All three genera are evolute forms with ventrolateral nodes and lateral ribs. *Dzhulfites* was defined as having a subquadrate whorl section, *Paratirolites* a subtrapezoidal one, and *Abichites* a whorl section that is somewhat compressed and subquadrate. It is in the suture that one can see the close genetic relationship between these three "genera." The suture is unique because of the low saddle separating two denticulated lateral lobes. Unfortunately, the ontogenetic development of the suture is not known, so that one cannot be sure if this is a true first lateral saddle or merely an adventitious indentation in a broad lateral lobe. Regardless of this, the patterns of the suture of all described species and genera are nearly identical (Text–fig. 12). Shevyrev distinguished *Dzhulfites* primarily on its simple-pronged ventral lobe, a character we feel is hardly of generic significance. Aside from the so-called simplicity of the ventral lobe in *Dzhulfites,* the overall shapes of the sutures of this genus and those of *Paratirolites* and *Abichites* are remarkably alike. There are, however, strong variations in whorl shape and ornamentation. In light of the identity of the sutures we regard the differences in whorl shape as indications of differentiation on the species level only. We thus believe that *Dzhulfites* and *Abichites* are synonyms of *Paratirolites.* The ten species of the Dzhulfitidae described by Shevyrev were distinguished largely on the basis of differences in ornamentation. Unfortunately, Shevyrev gave little or no data on the range of variability of each ornament pattern. Our collections of approximately 60 specimens clearly show that there is great variation in ornament pattern and much gradation. Experience with many large populations of ornamented Scythian ammonites has clearly demonstrated that node and rib patterns commonly are highly variable, both in numbers and in strength (Kummel and Erben, 1968; Kummel, 1969). In Soviet Dzhulfa the two recorded species of "*Dzhulfites*" came from a single thin stratum, as did the five species of *Paratirolites* and the three species of "*Abichites.*"

Until recently *Paratirolites* was considered an endemic genus confined to the Ali Bashi Formation and its equivalents in the Dzhulfa region. Now Taraz (1969) has reported the genus from the Abadeh region of central Iran, about 1,100 km (680 miles) southeast of Julfa. In addition Tozer (1969) reported that the holotype of *Xenodiscus douvillei* Diener (1914: 918, pl. 1, figs. 1a–d), from an unknown horizon in Madagascar, is a species of *Paratirolites.* Since it shows the characteristic suture, there is no reason to doubt this identification. The lack of stratigraphic data for this specimen is unfortunate, but this record does extend considerably the geographic range of *Paratirolites.*

Paratirolites kittli Stoyanow

Plate 6, figures 1, 3–5, 7, 10, 11; Plate 7, figures 3, 7, 9

Paratirolites Kittli Stoyanow, 1910: 82, pl. 9, figs. 1, 2; Spath, 1934: 366, fig. 125; Kiparisova, 1947: 169, pl. 40, fig. 4; Kummel *in* Arkell *et al.,*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1957: L147, fig. 179,1; Shevyrev *in* Ruzhentsev and Sarycheva, 1965: 174, pl. 22, fig. 4; Shevyrev, 1968: 90, pl. 3, fig. 1.

Stephanites? Waageni Stoyanow, 1910: 89, pl. 8, fig. 3; Kiparisova, 1947: 167, pl. 40, fig. 3.

Stephanites sp. ind. Stoyanow, 1910: 89, pl. 7, fig. 8.

Paratirolites waageni, Spath, 1934: 367; Shevyrev *in* Ruzhentsev and Sarycheva, 1965: 175, pl. 22, figs. 5, 6; Shevyrev, 1968: 90, pl. 2, figs. 6, 7.

Paratirolites vediensis Shevyrev *in* Ruzhentsev and Sarycheva, 1965: 176, pl. 23, fig. 1; Shevyrev, 1968: 92, pl. 5, fig. 1.

Paratirolites trapezoidalis Shevyrev *in* Ruzhentsev and Sarycheva, 1965: 177, pl. 24, fig. 1; Shevyrev, 1968: 92, pl. 4, fig. 1.

Discussion. This is by far the dominant species, approximately 60 specimens, of this genus in the Ali Bashi Formation at Kuh-e-Ali Bashi and in Soviet Dzhulfa. Our specimens are for the most part fragmentary but show clearly that there is great variation in whorl cross section and ornamentation. The few specimens illustrated on Plates 6 and 7 give some idea of this variation. Because of fragmentary preservation, our collection is not suited for a detailed analysis of this variation. However, because the specimens are all from a single unit (approximately 3 m thick) within a very limited geographic range, we believe it more prudent to assume they are a single species; otherwise the only limit on the number of species recognized would be the number of specimens available.

Occurrence. Loc. 1, 1 m above base of Paratirolites limestone (MCZ 9728, 9751, KU 73381–73386); Loc. 2, 13.5 m above base of formation (MCZ 9748); Loc. 2, 20 cm above base of Paratirolites limestone (MCZ 9731, 9733, 9749, KU 73396–73402); Loc. 3, 11 m above base of formation (MCZ 9783); Loc. 4, bed 5 (MCZ 9784); float from Ali Bashi Formation but exact locality unknown (MCZ 9730, 9735, 9737, 9740, 9742, 9746, KU 73403–73467).

Repository. MCZ 9728 (Pl. 6. fig. 1), MCZ 9730 (Pl. 6, figs. 3, 4), MCZ 9731 (Pl. 6, fig. 5), MCZ 9733 (Pl. 6, fig. 7), MCZ 9735 (Pl. 6, figs. 10, 11), MCZ 9737 (Pl. 7, fig. 3), MCZ 9740 (Pl. 7, fig. 7), MCZ 9742 (Pl. 7, fig. 9), unfigured specimens MCZ 9746, 9748, 9749, 9751, 9783, 9784; KU 73381–73386, 73396–73467.

Paratirolites spinosus (Shevyrev)

Plate 6, figures 2, 6; Plate 7, figures 4, 5, 10, 11

Dzhulfites spinosus Shevyrev *in* Ruzhentsev and Sarycheva, 1965: 173, pl. 21, fig. 9; pl. 22, fig. 1; Shevyrev, 1968: 88, pl. 2, figs. 3, 4; Taraz, 1969: 691.

Dzhulfites nodosus Shevyrev *in* Ruzhentsev and Sarycheva, 1965: 174, pl. 22, figs. 2, 3; Shevyrev, 1968: 89, pl. 2, fig. 5; pl. 3, fig. 4.

Discussion. The two species brought together here were assigned by Shevyrev (*in* Ruzhentsev and Sarycheva, 1965) to his new genus *Dzhulfites.* As stated above, we do not believe the differences between these forms and other paratirolitids sufficient to warrent separation on the generic level. As in Soviet Dzhulfa, the species at Kuh-e-Ali Bashi is not common. Our collections contain nine specimens.

Occurrence. Loc. 2, 13.5 m above base of formation (MCZ 9729); float from Ali

Text-figure 12. Diagrammatic representation of suture of ammonoids from the "Induan" of the Dzhulfa area: A, *Dzhulfites spinosus* (1965, fig. 14a), at a whorl height of 20.3 mm; B, *Dzhulfites spinosus* Shevyrev (1965, fig. 14b), at a whorl height af 18.5 mm; C, *Dzhulfites nodosus* Shevyrev (1965, fig. 14c), at a whorl height of 27.9 mm; D, *Paratirolites kittli* (Shevyrev, 1965, fig. 15a), at a whorl height of 15.8 mm; E, *Paratirolites kittli* (Shevyrev, 1965, fig. 15b), at a whorl height of 9.7 mm; F, *Paratirolites waageni* (Shevyrev, 1965, fig. 16a), at a whorl height of 25.2 mm; G, *Paratirolites waageni* (Shevyrev, 1965, fig. 16b), at a whorl height of 23 mm; H, *Paratirolites waageni* (Shevyrev, 1965, fig. 16c), at a whorl height of 17.8 mm; I, *Paratirolites vediensis* Shevyrev (1965, fig. 17a), at a whorl height of 17.6 mm; J, *Paratirolites trapezoidalis* Shevyrev (1965, fig. 17b), at a whorl height of 24 mm; K, *Paratirolites trapezoidalis* Shevyrev (1965, fig. 17c), at a whorl height of 14.6 mm; L, *Paratirolites dieneri* (Shevyrev, 1965, fig. 18), at a whorl height of 10.5 mm; M, *Abichites mojsisovicsi* (Shevyrev, 1965, fig. 19a), at a whorl height of 12.2 mm; N, *Abichites stoyanowi* Shevyrev (1965, fig. 19b), at a whorl height of 11.9 mm; O, *Abichites stoyanowi* Shevyrev (1965, fig. 19c), at a whorl height of 13 mm; P, *Abichites abichi* Shevyrev (1965, fig. 19d), at a whorl height of 10.3 mm. [All references to Shevyrev, 1965, are to Shevyrev *in* Ruzhentsev and Sarycheva, 1965.]

Bashi Formation but exact locality unknown (MCZ 9732, 9738, 9743, 9747, KU 73392–73395).

Repository. MCZ 9729 (Pl. 6, fig. 2), MCZ 9732 (Pl. 6, fig. 6), MCZ 9738 (Pl. 7, figs. 4, 5), MCZ 9743 (Pl. 7, figs. 10, 11), unfigured specimens MCZ 9747, KU 73392–73395.

Paratirolites mojsisovicsi (Stoyanow)

Plate 6, figures 8, 9; Plate 7, figures 1, 2, 6, 8

Xenodiscus (*Paratirolites?*) *Mojsisovicsi* Stoyanow, 1910: 79, pl. 8, fig. 1.

Abichites mojsisovicsi, Shevyrev *in* Ruzhentsev and Sarycheva, 1965: 180, pl. 23, fig. 4; Shevyrev, 1968: 95, pl. 4, fig. 3.

Xenodiscus radians Stoyanow, 1910: 86, pl. 9, fig. 5.

Xenodiscus sp. ind. Stoyanow, 1910: 87, pl. 9, fig. 6.

Kashmirites? stoyanowi Kiparisova, 1947: 149, pl. 35, fig. 1.

Abichites stoyanowi, Shevyrev *in* Ruzhentsev and Sarycheva, 1965: 179, pl. 24, figs. 2, 3; Shevyrev, 1968, pl. 3, fig. 5, pl. 4, fig. 2; Taraz, 1969: 691.

Abichites abichi Shevyrev *in* Ruzhentsev and Sarycheva, 1965: 181, pl. 24, fig. 4; Shevyrev, 1968: 181, pl. 24, fig. 4.

Paratirolites Dieneri Stoyanow, 1910: 83, pl. 8, fig. 2; Spath, 1934: 366, fig. 125e; Shevyrev *in* Ruzhentsev and Sarycheva, 1965: 178, pl. 23, figs. 2, 3; Shevyrev, 1968: 93, pl. 3, figs. 2, 3.

Discussion. Brought together here are the more compressed paratirolitids for which Shevyrev (*in* Ruzhentsev and Sarycheva, 1965) established the genus *Abichites.* These forms are only slightly more common than those assigned to *Dzhulfites* but still far inferior in numbers to *Paratirolites kittli* in our collections from Kuh-e-Ali Bashi and in Shevyrev's collections from Soviet Dzhulfa. Our collections contain only four specimens, but they are rather well preserved. The species brought together here were originally differentiated on minor variations in ornament or whorl shape.

Occurrence. Loc. 1, 1 m above base of Paratirolites limestone (MCZ 9734); Loc. 2, 9 m above base of formation (MCZ 9736); Loc. 3, 3 m above base of formation (MCZ 9739); from unknown horizon and locality in Ali Bashi Formation MCZ 9741, KU 73387–73391.

Repository. MCZ 9734 (Pl. 6, figs. 8, 9), MCZ 9736 (Pl. 7, figs. 1, 2), MCZ 9739 (Pl. 7, fig. 6), MCZ 9741 (Pl. 7, fig. 8), unfigured specimens KU 73387–73391.

Phylum ARTHROPODA

Class CRUSTACEA Pennant, 1777

Subclass OSTRACODA Latreille, 1806

Orders *PALAEOCOPIDA* Henningsmoen, 1953, and *PODOCOPIDA* Müller, 1894

Ostracods are quite common in rocks of the Ali Bashi Formation, but we succeeded in securing only a very few identifiable specimens. Out of 37 thin sections of Ali Bashi rocks, ostracods were present in 26, and in many of these in considerable abundance (Pl. 14). The small assemblage that I. G. Sohn (written communication to Teichert, 21 December 1971) was able to identify has already been mentioned. It came from the very base of the *Paratirolites* beds at Locality 1.

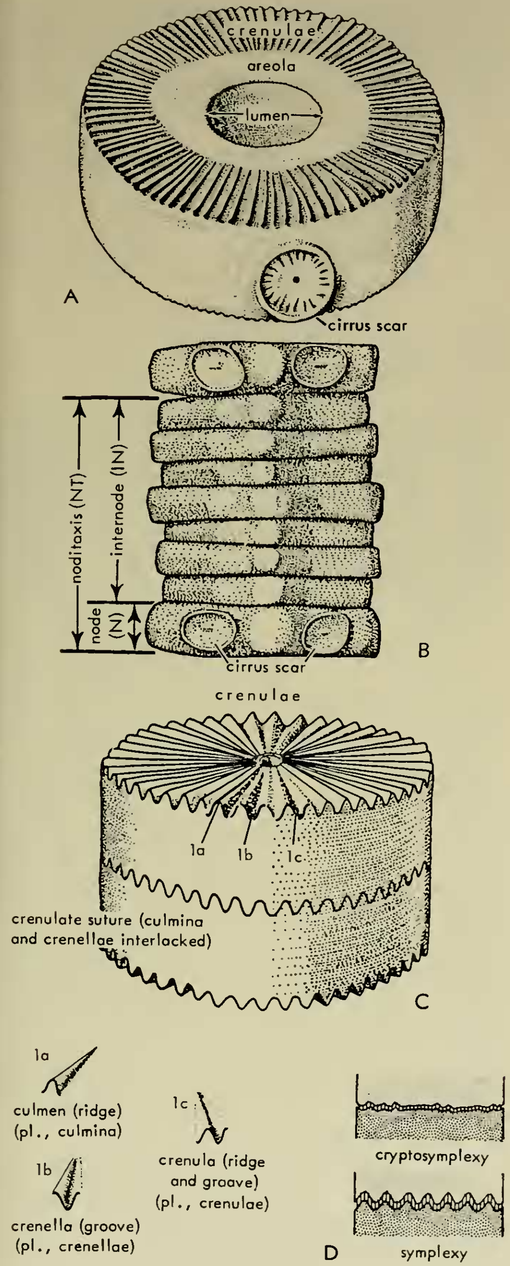
According to Sohn, the carapace of *Hollinella* sp. cf. *H? tuberculata* Belousova, 1965, has a straight frill and a configuration of nodes and lobe similar to the specimen figured by Belousova in Ruzhentsev and Sarycheva (1965, pl. 46, fig. 2a). In addition this small assemblage includes species of *Bairdia* and other indeterminate Bairdiacea.

Phylum ECHINODERMATA

Class CRINOIDEA Miller, 1821

INTRODUCTION

Our collections include about 50 parts of crinoid stems, occurring both as columnals and pluricolumnals. Since Moore and Jeffords (1968) have demonstrated that the study of dissociated columnals of crinoids is of potential stratigraphic value, and since very little is known of Permian crinoid columnals, we decided to describe our crinoid material in some detail. In describing the morphological features of the columnals, we follow closely the morphological



Text-figure. 13. Some morphological features of crinoid columnals and pluricolumnals. A. Single columnal showing nearly straight sides and features of the facet. B. Side view of pluricolumnal showing nodals with cirrus scars, and internodals of three orders, entire noditaxis composed of eight columnals. C. Straight-sided columnals joined by interlocked ridges and grooves of articular surfaces marked externally by crenulote suture, single ridge (1a, culmen) and groove (1b, crenella) together forming a crenula (1c). D. Diagrammatic transverse profiles of juxtaposed articular facets showing two types of articulation described in this paper. (From Moore, Jeffords, and Miller, 1968a, fig. 1. Published by permission of the authors.)

terminology proposed by Moore, Jeffords, and Miller (1968a). For the benefit of readers who are not familiar with this terminology, which is largely new, or who do not have easy access to the original publication, some diagrammatic figures published by Moore, Jeffords, and Miller (1968a, figs. 1 and 2) are here reproduced (Text–fig. 13). They are essentially self-explanatory, but for further guidance the following explanations of new or little-known terms are supplied. They are copied from Moore, Jeffords, and Miller (1968a: 27–30).

Glossary of Selected Terms Applied to Crinoid Parts

areola (pl., **areolae**). Generally smooth, featureless area of columnal articulum between lumen (or perilumen, if present) and inner margin of crenularium; may be granulose or marked by fine vermicular furrows and ridges.

articulum (pl., **articula**). Smooth or sculptured surface of columnal or cirral serving for articulation with contiguous stem element, may be intercolumnal, intercirral, or nodicirral (between nodal columnal and most proximal cirral); *syn.*, articular facet. All columnal and cirral articula are divisible into lumen and surrounding area designated zygum.

axial canal. Longitudinal passageway penetrating columnals and cirrals, generally but not invariably located centrally; may be single and either simple or complex or multiple (main canal accompanied by smaller accessory canals).

claustrum (pl., **claustra**). Thick or thin inward projection of columnal medulla constricting axial canal, inner extremity acuminate to bluntly rounded, truncate with rabbeted edges, or clavate, composed of dense stereom or showing microstructure of fine annular lamellae subparallel to mid-plane of columnal, with or without intersecting longitudinally disposed lamellae which form microscopic cribwork.

crenularium (pl., **crenularia**). Portion of columnal and cirral articula occupied by crenulae.

heteromorphic (column or pluricolumnal). Sequent columnals dissimilar, some consisting of nodals and others of internodals, latter commonly divisible by order of their intercalation into prim-, secund-, tert-, and quartinternodals or higher-rank ones. Nodals and internodals may be clearly distinguishable along sides of axial canal, as seen in longitudinal sections, but not in views of columnal latera.

homeomorphic (column or pluricolumnal, cirrus or pluricirral). Composed of identical or essentially identical skeletal elements. Pluricolumnals from different parts of xenomorphic crinoid columns may be homeomorphic within themselves but dissimilar when compared with one another.

jugulum (pl., **jugula**). Localized constriction of axial canal produced by approximated adaxial edges of claustrum, may be longitudinally very short to moderately tall and transversely circular or pentagonal to strongly pentastellate.

latus (pl., **latera**). Surface of crinoid columnal or cirral exclusive of articular facets, equivalent to epifacet.

perilumen (pl., **perilumina**). Raised inner border of columnal articular zygum, surrounding lumen as rim or tabular field with smooth, granulose, tuberculate, or vermiculate surface. Internally, perilumen of some columnals corresponds to dense inner medulla, which is very distinct from reticulate to spongy outer medulla between areolae and possibly part of crenularia of opposite articula.

pluricolumnal. Two or more columnals attached to one another.

spatium (pl., **spatia**). Localized widening of columnal axial canal opposite interarticular sutures.

zygum (pl., **zyga**). All of columnal or cirral articulum surrounding lumen.

For further guidance of the reader, the following list of explanations of symbols used in text and tables of the present paper is given.

Explanation of Symbols Used in this Paper

A —Areolar width: twice the interval between two radial intercepts of the areola.

Ai —Areolar index: $\frac{A}{KD}$.

C —Crenularial width: twice the interval between two radial intercepts of the crenularium.

Ci —Crenularial index: $\frac{C}{KD}$.

IN —Internodal (without cirri).

KD —Columnal diameter (for straight-sided columnals this is also the width of the articular facet).

KH —Columnal height, longitudinal dimension of columnal.

KHi —Columnal height index: $\frac{KH}{KD}$.

L —Luminal diameter.

Li —Luminal index: $\frac{L}{KD}$.

N —Nodal; having one or more cirri.

P —Periluminal width: twice the interval between radial intercepts of the perilumen.

Pi —Periluminal index: $\frac{P}{KD}$.

SPM —Specimen.

We have given much consideration to the question of whether or not we should formally name the crinoid specimens studied by us in the manner proposed by Moore and Jeffords (1968) and practiced by Soviet paleontologists such as Yu. A. Dubatolova, G. A. Stukalina, and R. S. Yeltysheva (cited in Moore, Jeffords, and Miller, 1968b: 12, 14). However, we decided to divide up our material into informally named types. Obviously, all specimens are similar enough morphologically that they must belong to one genus. However, we find it difficult to decide whether or not these "types" represent taxonomic units on the species-group level. Further, we show that the bulk of the specimens seems to be parts of juvenile individuals. Lastly, there is a strong possibility that all specimens may belong to an already named species of fistulate crinoids, *Erisocrinus araxensis* Yakovlev (1933). These considerations form the basis for our decision not to apply formal taxonomic names to the crinoid remains from the Ali Bashi Formation.

For purposes of comparison, we have included in this study the description of a few crinoid columnals from the Julfa beds that underlie the Ali Bashi Formation.

At the University of Kansas, R. C. Moore has assembled, over a period of years, what is probably the world's largest collection of disarticulated crinoid remains, including stem fragments. It has, of course, been impossible to check these huge collections. We have, however, selected a few specimens from Pennsylvanian and Permian rocks for comparative studies. We wish to thank Dr. Moore for his permission to study these specimens.

SYSTEMATIC DESCRIPTIONS

Order and family uncertain

Type 1

Plate 10, figures 5, 15

Description. Known only from internodals that are circular to elliptical in transverse section, straight latera; articulation unknown, probably symplectic or cryptosymplectic; articular facet with medium culmina that retain approximately the same thickness throughout their length; broad areola; perilumen absent or very faint; small, circular lumen; number of culmina 22 or 23. Measurements (in mm) and indices of specimen KU 73118 are: KD, 3.8; L, 0.3; Li, 18.1; A, 2,3; Ai, 60.0; C, 0.7; Ci, 34.0; KH, 3.5; KHi, 91.0.

Discussion. The collection contains one specimen definitely assignable to Type 1. A second specimen has no perilumen but is elliptical in transverse section. Illustrated specimens that resemble Type 1 include *Cyclocyclicus schizinicus* Dubotolova and Shao-Tze (1959, pl. 1, figs., 18a,b) from the Middle Triassic of northern China which differs only in having a more squared symplectic articulation (see fig. 18b, longitudinal view). *Erisocrinus araxensis* Yakovlev (1933; Yakovlev and Ivanov, 1956, pl. 19, figs. 2a,b) probably bears the closest resemblance to Type 1 (Pl. 10, figs. 1a,b). This species occurs in the uppermost Permian beds at Dorasham near Dzhulfa in the Nakhichevan ASSR. Unfortunately, a second crinoid species, *Spaniocrinus transcaucasicus* Yakovlev (1933), which occurs in the same beds, cannot be compared because its columnals are not known.

Forms similar in circular to elliptical cross section are *Encrinus liliiformis* (Quenstedt, 1876, pl. 107, fig. 18) from the Middle Triassic of southern Germany and *Eugeniacrinus compressus* (*ibid*, pl. 106, fig. 19) from the Upper Jurassic of southern Germany. Both species have small lumina, well-developed crenularia, an areola, and no perilumen.

Specimen PH 105 from the Word Formation (Guadalupian) of the Glass Mountains, Texas, which is in the R. C. Moore collection of the Paleontological Institute, University of Kansas, resembles Type 1 except for greater convexity of its latera and the possible presence of a spatium.

Measurements and indices for specimens in published literature and from the R. C. Moore collection are given in Tables 2 and 3.

Occurrence. Loc. 3A, bed 2.

Repository. KU 73118 (Pl. 10, figs. 15a, b), possibly 73151 (Pl. 10, fig. 5).

Type 2

Plate 10, figures 3, 9, 10, 11, 14

Description. Stem heteromorphic, circular to elliptical in transverse section; nodals and internodals present; diameter of cirrus scars not greater than one-half the height of columnals; latera concave, convex, or straight; articulation cryptosymplectic; articular facet small with relatively fine culmina and crenellae; culmina probably develop by bifurcation from 15 original ones, which remain as bumps on the inner margin of the crenularium, others intercalated between bifurcating pairs, probably in manner similar to that described by Bather (1917: 250–251); medium to broad crenularium; areola of medium to narrow width but always present; perilumen present, approximately circular. Measurements and indices are given in Table 4.

Discussion. A specimen with elliptical transverse section (KU 73154) has the same articular pattern and so is included in this group; it has approximately 30–45 culmina including intercalated ones. Specimens intermediate between Types 2 and 3 in number of culmina exist (KU 73120, 73138). Type 2 specimens from Locality 3A, bed 2, seem to have a smaller Ci and a larger Ai than those from Locality 4, bed 3. The relationship between the diameters of colum-

Table 2. Measurements (in mm) and Indices for Crinoid Stems from the Literature

SPM	KD	L	Li	P	Pi	A	Ai	C	Ci	KH	KHi	Similar to Type
1 a (upper)	8.5	0.8	9.4	0	0	4.2	49.5	3.2	37.6	4.5	53.0	1
b (lower)	8.5	1.9	22.5	0	0	4.0	47.1	2.2	26.0	—	—	1
2	11.5	1.5	13.1	0	0	5.0	43.5	5.0	43.5	5.5	48.0	1
*3	7.2	0.4	5.6	0	0	4.4	61.1	2.2	30.5	7.6	106.0	1
*4	12.0	0.9	7.5	0	0	9.0	75.0	3.4	28.0	9.5	79.0	1
5	3.0	0.6	19.2	0	0	1.4	47.0	1.0	34.0	3.0	100.0	1
6	9.0	0.7	7.7	0	0	6.9	77.0	1.4	15.0	6.2	69.0	1
*7 a	4.0	—	—	—	—	—	—	—	—	3.1	78.0	1
b	4.9	0.3	9.1	0	0	3.3	68.0	1.3	28.0			1
8	4.4	0.7	16.1	0	0	2.7	61.0	1.0	23.0	—	—	1
9	7.0	1.0	14.3	0	0	2.2	31.4	3.0	42.8	1.5	21.4	1
10	5.7	0.8	14.1	0	0	1.5	26.3	3.0	52.6	1.4	24.6	1
11	2.9	0.5	16.9	0	0	1.3	43.1	1.0	32.3	—	—	1
12	2.5	0.3	13.0	0.7	22.0	1.5	58.0	0.5	20.0	1.5	60.0	3

* These specimens have measurements and indices with closest resemblance to those described in this report.
1. *Apiocrinus* stem, Upper Jurassic, southern Germany (Quenstedt, 1876, pl. 102, fig. 14)
2. *Apiocrinus* stem, lower Upper Jurassic, southern Germany (Quenstedt, 1876, pl. 104, fig. 7)
3. *Encrinus liliiformis*, Middle Triassic (Hauptmuschelkalk), Germany (Quenstedt, 1876, pl. 107, fig. 18)
4. *Cyclocyclicus schizinicus*, Middle Triassic, northern China (Dubatolova and Shao-Tsze, pl. 1, figs. 18a,b)
5. *Erisocrinus araxensis*, Upper Permian, Dorasham, near Dzhulfa, USSR (Yakovlev and Ivanov, 1956, pl. 19, figs. 2a,b)
6. *?Philocrinus cometa*, Upper Permian, Salt Range, West Pakistan (Waagen, 1885, pl. 95, figs. 20, 20a)
7. *?Philocrinus cometa*, Upper Permian, Salt Range, West Pakistan (Waagen, 1885, pl. 95, figs. 20b,c)
8. *Cyathocrinus kattaensis*, Upper Permian, Salt Range, West Pakistan (Waagen, 1885, pl. 96, fig. 2g)
9. *Parastachyocrinus malaianus* var. *ornata*, Upper Permian, Timor (Wanner, 1949, pl. 3, fig. 19)
10. *Cyathocrinus berkaloffi*, Permian, Tunisia (Valette, 1934, figs. 12, 12a)
11. *Cyathocrinus berkaloffi*, Permian, Tunisia (Valette, 1934, figs. 12b,c)
12. "*Cyathocrinus*" *goliathus*, Permian, Tunisia (Termier and Termier, 1958, pl. 2, figs. k,l)

nals and the number of culmina is shown in Text–figure 14.

A specimen in the R. C. Moore collection, BA 55 6c (Pennsylvanian, South Bend, Young Co., Texas), probably representing *Cyclocaudex*, resembles specimen KU 73154 in Ci and Ai but has a much larger lumen and smaller columnal height. Measurements and indices for the specimens here discussed are found in Tables 2 and 3.

Occurrence. Loc. 3A, bed 2; Loc. 4, bed 3.

Repository. KU 73119 (Pl. 10, figs. 14a, b), 73149 (Pl. 10, figs. 10a,b), 73154 (Pl. 10, fig. 3), 73165 (Pl. 10, figs. 9a,b), 73166 (Pl. 10, fig. 11). Unfigured specimens KU 73121 and 73152, and possibly 73120 and 73156.

Type 3

Plate 10, figures 2, 4, 6, 8, 12

Description. Stem heteromorphic, appearing homeomorphic in some specimens; of small size; in a few specimens with cirri on adjacent columnals; latera straight or convex; cirrus scars of small width, generally not over one-half the height of columnals; articulation symplectic; articular facet with medium to broad culmina and crenellae; narrow crenularium, areola broad, slightly ornamented; perilumen present, poorly to moderately well differentiated from areola; lumen small and circular, possibly pentagonal in specimen KU 73155. Measurements and indices are given in Table 4.

Discussion. This type generally has 16 to 30 culmina all of equal size and importance. Shape and texture of the perilumen vary: some specimens have a circular perilumen with knoblike culmina, others have loaflike culmina. The relationships between the length of columnals and number of culmina are shown in Text–figure 15.

Illustrated specimens from the literature which resemble Type 3 include "*Cyathocrinus*" *goliathus* Waagen of Termier and Termier (1958, pl. 2, fig. K) from the Permian of southern Tunisia and *Erisocrinus stefaninii* Yakovlev (1934, pl. 20, figs. 4a,

TABLE 3. MEASUREMENTS (IN mm) AND INDICES FOR CRINOID STEMS IN R. C. MOORE COLLECTION, SIMILAR TO CRINOIDS FROM ALI BASHI FORMATION

SPM	KD	L	Li	P	Pi	A	Ai	C	Ci	KH	KHi	Similar to Type
AK64												
(facetal view)	1.6	0.2	1.1	0	0	0.8	47.7	0.4	39.0	—	—	1
(side view)	1.7	—	—	—	—	—	—	—	—	1.4	82.0	
AK65												
(facetal view)	2.0	0.3	17.0	0	0	1.0	51.0	0.5	26.0	—	—	1
(side view)	1.9	—	—	—	—	—	—	—	—	2.5	126.0	
*PH105												
(v. convex latera) spatium?	6.5	0.7	10.5	0	0	4.2	64.0	1.8	28.0	5.8	89.0	1
BA55 6c												
(facetal view)	4.7	0.1	21.3	0.6	12.8	0.7	14.8	2.9	62.0	—	—	2
(side view)	4.6	—	—	—	—	—	—	—	—	1.6	29.0	
AK59 5d												
(facetal view)	3.3	0.5	15.2	0.4	12.1	1.0	30.4	1.3	38.0	—	—	3
(side view)	3.4	—	—	—	—	—	—	—	—	2.6	77.0	
*PH44												
(pent. areola)	6.4	0.5	8.0	0.9	14.0	3.7	58.0	1.8	28.0	2.8	44.0	3
PH79	3.6	0.5	13.8	0.5	14.0	1.5	42.0	1.2	36.0	2.5	70.0	3

Localities:
AK Mingus Shale Member, Garner Formation, Strawn Group, Desmoinesian, Middle Pennsylvanian, Erath Co., Texas
BA South Bend Shale Member, Graham Formation, Cisco Group, Virgilian, Upper Pennsylvanian, Young Co., Texas
PH Middle Limestone 2, Word Formation, Guadalupian, Upper Permian, Glass Mountains, Brewster Co., Texas
* These specimens have measurements and indices with closest resemblance to those described in this report.

b) from the Upper Permian of Sicily.

Specimen PH 44 in the R. C. Moore collection, from the Word Formation (Guadalupian), Glass Mountains, Texas, resembles Type 3 in measurements and indices but has a slightly pentagonal areola. Measurements and indices of specimens from the literature and from the R. C. Moore collection are given in Tables 2 and 3.

Occurrence. Loc. 4, beds 2 and 3.

Repository. KU 73147 (Pl. 10, fig. 4), 73150 (Pl. 10, fig. 2), 73155 (Pl. 10, figs. 8a, b), 73159 (Pl. 10, figs. 12a,b), and possibly 73138 (Pl. 10, fig. 6). Unfigured specimens KU 73125, 73134, 73135, 73137, 73142, 73164.

Type 4

Plate 10, figures 7, 16

Description. Stem heteromorphic, circular in transverse section; nodals and internodals present; latera straight; articulation cryptosymplectic; articulum with 36–40 fine culmina including intercalated ones, bifurcating from 15 more or less distinct knobs or intercalating between bifurcating culmina; areola of medium width; perilumen present with knoblike culmina; small, circular lumen. Measurements and indices for specimens KU 73157 and KU 73303 are given in Table 4.

Discussion. Specimens KU 73157 and

TABLE 4. MEASUREMENTS (IN mm) AND INDICES FOR CRINOIDS FROM ALI BASHI FORMATION

SPM	KD	L	Li	P	Pi	A	Ai	C	Ci	KH	KHi	N or IN
Type 1												
1	3.8	0.31	8.1	0	0	2.3	60.0	1.3	34.0	3.5	90.8	IN
41	2.6	0.23	8.0	0	0	1.7	68.0	0.6	43.0	3.7	102.5	IN
Type 2												
2	3.7	0.30	8.4	0.7	18.8	1.0	27.0	1.7	44.5	4.4	119.0	IN
5	3.0	0.35	11.2	0.6	20.0	1.4	46.5	0.7	43.0	3.7	121.5	IN(?)
39A	3.9	0.46	8.4	0.5	11.6	1.7	45.0	1.1	36.5	3.7	95.8	IN
B	3.8	0.26	6.8	0.6	16.8	1.8	47.0	1.1	34.8	4.5	118.0	IN
42A	4.8	0.41	8.6	0.8	17.2	1.8	38.0	1.5	31.1	5.2	109.0	N
B	4.9	0.41	8.6	0.9	18.2	1.5	33.0	1.5	32.5	4.8	98.2	N
44	3.2	0.23	7.1	0.6	17.6	0.4	14.0	2.0	59.0	3.9	121.8	IN
50	4.4	0.40	9.1	1.9	43.5	0.4	9.1	1.8	42.3	5.9	139.8	N
59A	4.0	0.32	7.9	1.3	32.0	0.8	18.9	1.6	39.5	4.4	107.9	N
B	4.0	0.37	9.3	0.9	22.0	1.1	25.5	1.7	42.5	3.5	86.5	IN
Type 2 or 3												
4	3.8	0.35	9.3	0.4	9.2	1.3	33.0	1.8	47.5	5.1	132.0	N(?)
28A	3.3	0.52	6.4	0.8	22.5	1.0	30.0	0.8	41.5	3.9	116.2	N
Type 2 or 4												
46	3.6	0.40	9.1	0.6	16.6	1.8	50.0	1.3	36.1	6.6	182.0	IN
Type 3												
8	3.6	0.40	8.9	0.3	16.8	0.6	36.0	0.8	42.3	3.6	66.1	IN
11B	3.1	0.40	7.7	0.6	19.4	1.0	32.5	1.0	32.0	3.0	97.1	IN
14	3.0	0.25	8.4	0.9	28.4	0.9	33.3	0.8	37.5	5.0	164.5	N
25A	3.0	0.35	8.6	0.8	26.0	1.1	36.6	0.8	36.5	2.1	69.9	IN
37A	2.8	0.20	7.2	0.9	25.0	1.1	39.5	0.5	18.6	4.4	64.5	N
B	2.8	0.30	10.7	0.6	20.5	1.5	54.0	0.4	14.1	3.0	93.5	N
40A	2.8	0.26	9.1	0.6	20.7	1.0	30.0	1.0	35.5	3.2	114.0	IN
D	3.0	0.26	8.8	0.6	20.9	1.3	42.5	0.6	46.0	3.0	100.2	IN
45A	3.9	0.43	9.0	0.7	18.6	1.2	31.6	1.2	31.6	5.2	132.1	N
B	3.8	0.36	9.6	0.6	17.0	0.9	42.0	1.2	32.0	4.7	118.0	N
49A	2.3	0.35	6.5	0.4	15.4	0.6	38.0	0.7	32.5	4.2	183.8	N
C	2.2	0.38	5.9	0.3	15.1	1.0	44.0	0.5	20.5	4.1	182.0	N
55A	4.0	0.30	7.4	0.8	19.6	1.3	31.0	1.3	32.0	3.3	79.9	N
Type 4												
47	4.5	0.47	9.5	0.6	13.4	1.2	27.0	2.3	51.5	4.7	104.3	IN
54A	3.0	0.40	7.6	0.6	18.2	0.7	44.5	1.2	39.0	3.0	99.9	IN

73303 are provisionally separated into a fourth group closely related to Type 2. They differ from Type 2 in their possession of a slightly larger lumen and a perilumen with knoblike culmina rather than loaflike ones. The border between areola and crenularium is less distinct than in some specimens of Type 2, and the culmina are finer. Types 2 and 4 both possess bifurcation from 15 main culmina with others intercalating between them. Specimen KU 73156 appears to be intermediate between Types 2 and 4 in the distinctness of separation of the areola and crenularium and in fineness of the culmina. No specimens from the literature or from the R. C. Moore collection from the Glass Mountains of Texas appear to resemble Type 4.

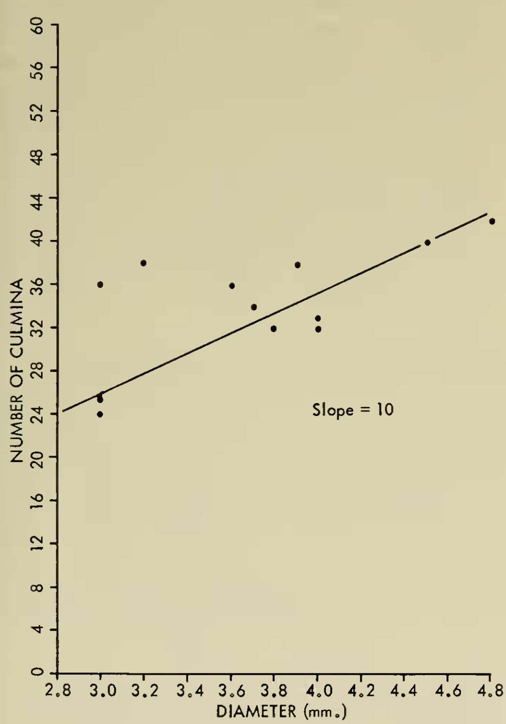
Occurrence. Loc. 4, bed 3; Loc. 3A, bed 2.

Repository. KU 73157, (Pl. 10, figs. 16a, b) and 73303 (Pl. 10, fig. 7), possibly also KU 73146 and 73156.

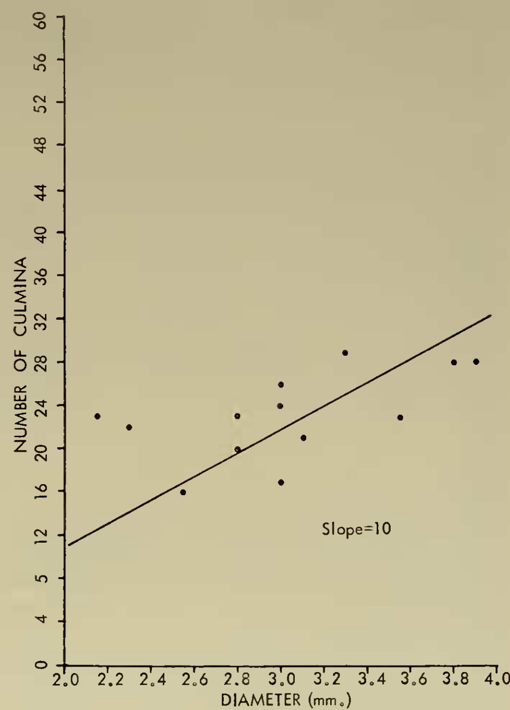
Comments on Growth and Classification

Several lines of evidence suggest that the Ali Bashi crinoids were in an early stage of growth. A plot of columnal diameter versus number of culmina suggests that they are most closely related to Jeffords and Miller's (1968: 11) columnal growth Type 1. The appearance of a specimen of Type 3 sectioned longitudinally also resembles their figure 4A. According to Jeffords and Miller (1968: 6–7), juveniles of columnal growth Type 1 have a diameter of approximately 4–5 mm or less, about 35 culmina, and a lumen 1–2 mm wide. KHi probably decreases with age, so that juveniles would have a greater KHi than adults. The nodals of the Ali Bashi specimens have a KHi of more than 100 except for specimens KU 73164 and KU 73153. Both of these specimens have diameters of more than 4.0 mm. The presence of nodals adjacent to each other or with only two or three internodals in the noditaxis also suggests that the crinoids were young.

The presence of a perilumen seems to be



Text-figure 14. Relationship of diameter of columnals to number of culmina (counted at periphery) in Type 2 specimens.



Text-figure 15. Relationship of columnals to number of culmina (counted at periphery) in Type 3 specimens.

the main feature that distinguishes Type 3 from Type 1. The similarity of the growth-index lines for Type 2 and 3 also suggests a relationship between them (Text–figs. 14, 15). Sufficient data were not available to approximate the growth-index lines of Types 1 and 4.

On the basis of similarities between types and with the published illustrations, one or more of the described types may belong to the genus *Erisocrinus*. Similarity to published illustrations and proximity to localities where representatives of this genus were collected suggest relationship to *Erisocrinus araxensis* from the Upper Permian of Dorasham near Dzhulfa, Nakhichevan ASSR, for at least Type 1 specimens (Pl. 10, figs. 1a,b). Some species of *Erisocrinus* have a perilumen, others do not. *E. araxensis* (Yakovlev, 1933, pl. 1, figs. 4, 5a) has none, while *E. stefaninii* (Yakovlev, 1934, pl. 20, fig. 4a) does. Unfortunately, it is not known whether the type material of *E. araxensis* comes from equivalents of the Julfa beds or of the Ali Bashi Formation.

Crinoid Stems from the Julfa Beds

Rather surprisingly, crinoid stems seem to be extremely rare in the Julfa beds that underlie the Ali Bashi Formation. Among hundreds of fossils in our collections from these beds, only five crinoid stems are present. They are, in some respects, similar to the Ali Bashi crinoids but differ in some features.

Type 5

Plate 10, figures 13a, b

Description. Stem heteromorphic; latera strongly convex, some having an incipient equatorial keel; less than three cirrus scars per nodal; diameter of cirrus scars less than one-third of the height of columnal; nodals slightly higher than internodals; lumen circular to slightly elliptical, about one-fifth to one-fourth of facetal diameter (which is larger than in any Ali Bashi crinoids); narrow perilumen present; crenularium of medium width with 22 to 27 medium-width culmina that retain the same width throughout; symplectic articulation; areola rather narrow and concave; border between areola and crenularium distinct. Measurement and indices for the three specimens are given in Table 5.

Discussion. These specimens differ from Type 3 Ali Bashi crinoids in having a larger lumen and a smaller perilumen. The areola is also smaller and better defined. The culmina resemble those of Type 1 more than those of the other three Ali Bashi types but are less square. In facetal view, the Julfa crinoids resemble *Preptopremnum rugosum* Moore and Jeffords (1968, pl. 27, figs. 4, 7a) from the Chaffin limestone member of the Thrifty Formation, Cisco Group, Virgilian, Upper Pennsylvanian of Texas, and *Preptopremnum laeve* (*ibid.*, pl. 27, figs. 11a,b) from the Mingus Shale, Strawn Group, Desmoinesian, Middle Pennsylvanian, Texas. *P. rugosum* has ornamentation not discerned on the latera and areola of the Julfa crinoids, however. A close resemblance to specimen Yl in the R. C. Moore collection from the Waldrip limestone, no. 3, Wolfcampian, Lower Permian, McColloch County, Texas, is also noted. A jugulum is present in the Texas specimen. No axial canal structures could be identified in the Julfa specimens. Thirty-three culmina were present in the larger diameter Texas specimen, a maximum of 27 in the Julfa crinoids. Measurements and indices for specimens from the literature and from the R. C. Moore collections are given in Tables 2 and 6.

Table 5. Measurements (in mm) and Indices for Crinoids from Julfa Beds

SPM		KD	L	Li	P	Pi	A	Ai	C	Ci	KH	KHi	No. of culmina
J17	A	4.6	—	—	—	—	—	—	1.8	—	2.7	59.0	22
	B	4.6	—	—	—	—	—	—	—	—	2.4	52.0	—
(nodal)	C	5.1	—	—	—	—	—	—	—	—	2.9	57.0	—
	D	4.6	—	—	—	—	—	—	—	—	2.5	55.0	22
J16 (larger)													
	A	4.6	0.9	19.6	1.0	22.0	0.8	17.4	1.5	33.0	2.4	52.0	25
(nodal)	B	4.9	—	—	—	—	—	—	—	—	2.8	—	—
	C	4.7	—	—	—	—	—	—	—	—	2.5	—	—
	D	4.8	1.2	25.0	—	—	—	—	—	—	2.6	—	—
J16 (smaller)													
(nodal)	A	4.3	1.2	27.9	0.5	18.0	1.2	27.9	1.5	35.0	2.4	56.0	27
	B	4.4	—	—	—	—	—	—	—	—	2.0	46.0	—
(nodal)	C	4.5	1.2	26.6	0.6	15.0	1.0	22.3	1.5	34.0	2.7	60.0	22

Table 6. Measurements (in mm) and Indices for Crinoid Stems in R. C. Moore Collection Similar to Crinoids from Julfa Beds

SPM	KD	L	Li	P	Pi	A	Ai	C	Ci	KH	KHi	No. of culmina
AK40												
(facetal view)	3.5	1.0	28.6	0.6	7.1	0.4	11.4	1.6	45.7	—	—	28
(internodal view)	3.8	—	—	—	—	—	—	—	—	1.0	26.3	—
(nodal view)	3.8	—	—	—	—	—	—	—	—	2.0	52.6	—
AK43												
(facetal view)	3.7	0.9	24.3	0.7	18.9	0.8	21.6	1.4	37.9	—	—	25
(internodal view)	4.0	—	—	—	—	—	—	—	—	1.0	25.0	—
(nodal view)	4.0	—	—	—	—	—	—	—	—	2.0	50.0	—
AK45 5d[1]												
(facetal view)	3.7	1.1	28.4	0.6	16.2	0.8	21.6	1.0	27.0	—	—	28
(internodal view)	3.9	—	—	—	—	—	—	—	—	1.0	25.6	—
(nodal view)	3.9	—	—	—	—	—	—	—	—	1.8	46.1	—
AW59[2]												
(facetal view)	8.3	2.5	30.3	1.5	18.2	1.8	21.6	2.2	26.5	—	—	40
AW134												
(facetal view)	6.5	2.5	42.3	1.0	15.4	1.3	19.2	1.5	23.1	—	—	58
BA34												
(facetal view)	2.7	0.8	29.6	0.6	22.2	0.4	14.8	0.5	18.5	—	—	23
(side view)	2.8	—	—	—	—	—	—	—	—	1.4	50.0	—
PEG54												
(both views)	5.8	1.8	30.4	1.3	26.1	1.3	26.1	1.0	17.4	1.9	32.6	38
Y1												
(internodal view)	6.2	1.7	27.5	0.6	9.7	1.2	19.4	1.7	27.5	1.9	30.5	33
(nodal view)	6.2	—	—	—	—	—	—	—	—	3.4	55.0	—

AK —Mingus Shale Member, Garner Formation, Strawn Group, Desmoinesian, Middle Pennsylvanian, Erath Co., Texas
AW —Chaffin Limestone Member, Thrifty Formation, Cisco Group, Virgilian, Upper Pennsylvanian, Brown Co., Texas
BA —South Bend Shale Member, Graham Formation, Cisco Group, Virgilian, Upper Pennsylvanian, Young Co., Texas
PEG— Marble Falls Limestone, Atokan, Middle Pennsylvanian, San Saba Co., Texas
Y —Waldrip Shale Member (Waldrip Limestone 3), Pueblo Formation, Wichita Group, Wolfcampian, Lower Permian, McCulloch Co., Texas
For additional information on localities, consult Moore, Jeffords, and Miller (1968b: 2–4).
[1] Moore and Jeffords, 1968, pl. 27, fig. 11a, b
[2] Moore and Jeffords, 1968, pl. 27, fig. 7a

Occurrence. Julfa beds, below Ali Bashi Formation (vicinity of Loc. 4).

Repository. KU 73304 (Pl. 10, figs. 13a, b), unfigured specimen, KU 73305.

Phylum uncertain

CONODONTOPHORIDA Eichenberg, 1930

Although it is believed that the skeletal apparatuses of several of the species described on the following pages consisted entirely of elements of a single morphologic type, taxa recognized are conceived to be "multielement" genera and species. Because all samples came from a limited stratigraphic interval and from a small outcrop area, no statistical evaluation of the collections was attempted. However, data on distribution and frequency given in Tables 7, 8, and 10 should be useful for this purpose when combined with similar information from other regions and sections.

The abbreviation OSU, which precedes catalog designations for types and other figured specimens, refers to the Orton Museum of Geology, at The Ohio State University, where the specimens are housed. The prefixes 69SA, 69SB, and 69SC before sample numbers are Ohio State University section designations that identify samples from Teichert-Kummel field localities 1, 2, and 4 respectively. The sample identified as 67GH-28 was collected by Stepanov *et al.* (1969) and is from bed 67 of their Julfa section. That bed is in the interval 11.3 to 30.8 m above the base of the Elikah Formation.

Genus *Anchignathodus* Sweet, 1970

Type species, *Anchignathodus typicalis* Sweet, 1970

Anchignathodus was established (Sweet, 1970a) to include conodonts with a skeletal apparatus composed solely of bladelike elements having an inconspicuously denticulated anterior crest and a distinctly denticulated posterior process, which surmounts a broad cuplike basal cavity whose lateral extensions may bear one or several denticles. In addition to *A. typicalis*, based on Lower Triassic specimens from Pakistan, Sweet suggested that several previously named conodont species should also be included in *Anchignathodus*, which would then range from Lower Carboniferous into lowermost Triassic. Affinities of many of the Lower Carboniferous forms are uncertain, but inclusion of "*Spathodus*" *minutus* Ellison, 1941, and *Spathognathodus isarcicus* Huckriede, 1958, still seems appropriate. The new species described below is clearly a close morphologic relative of *A. typicalis*.

In Pakistan (Sweet, 1970b), in Kashmir (Sweet, 1970a), and in samples at hand (Table 7), elements of *Anchignathodus* are commonly, but not invariably, associated with those referred to *Ellisonia teicherti* Sweet. There is thus a possibility that all these elements were components of the same skeletal apparatuses, not of the apparatuses of species referable to two conodont genera. At present, however, Sweet prefers to recognize two generic groups, *Anchignathodus* and *Ellisonia*, for no *E. teicherti*-like elements occur with those of *A. isarcicus* in any of his samples from the Werfen Formation of northern Italy, and elements of *Anchignathodus* and *E. teicherti* have little in common either morphologically or structurally.

It should also be noted that Clark (1972) regards *Anchignathodus* as one of the few survivors of an early Permian "crisis" and the probable ancestor of Permian species he refers to the genera *Neostreptognathodus* and *Sweetognathus*. Although there is some question as to whether the latter two names are validly established in Clark's report, they are apparently based on well-known species (*Streptognathodus sulcoplicatus* Youngquist, Hawley and Miller, 1951, and *Spathognathodus whitei* Rhodes, 1963, respectively) and, with *Anchignathodus*, they are referred by Clark (1972) to a new superfamily, the Anchignathodontacea. Kozur (1971), on the other hand, lumps *A. typicalis* Sweet and *A. isarcicus* (Huckriede) together into a single species, *Spathognathodus isarcicus*, the concept of which must be nearly as broad as Clark's Anchignathodontacea.

Anchignathodus isarcicus (Huckriede)

Plate 11, figures 5–7

Spathognathodus isarcicus Huckriede, 1958: 162, 167, pl. 10. figs. 6, 7a–c; Staesche, 1964: 288–289, figs. 6, 60, 61, 62, 63, 64.

Anchignathodus isarcicus (Huckriede), Sweet, 1970b: 223–224, pl. 1, figs. 18, 19.

Staesche's (1964) detailed description and illustrations of the various skeletal ele-

TABLE 7. DISTRIBUTION AND FREQUENCY OF ALI BASHI AND LOWER ELIKAH CONODONTS[1]

Formation	Sample	M above base of formation	*Neogondolella orientalis*	*Neogondolella carinata subcarinata*	*Neogondolella carinata carinata*	*Xaniognathus* sp. cf. *X. elongatus*	*Anchignathodus julfensis*	*Anchignathodus typicalis?*	*Anchignathodus isarcicus*	*Ellisonia teicherti*	*Ellisonia gradata*	*Ellisonia* spp.
LOCALITY 1 (OSU SECTION 69SA)												
Elikah Fm.	C8	38.0										
	C7	31.5										
	C6	25.5										5
	C5	21.0										6
	C4	16.5				1						1
	C3	13.5						4		1		
	C2	7.5										
	C1	4.5						3	8	4		
	22U	0-1.0							30	6		
	22M	0-1.0							43	21		
	22L	0-1.0						3				1
Ali Bashi Fm.	21	18.0						1				
	20U	17.4		1	1					2		
	20M	16.4		107	12	9					7	
	20L	15.4		262	26	25					21	
	19U	15.0		4	2	1		1				
	19L	13.6		18	4	1					3	
	18U	12.9		88	14	1					1	
	18L	10.9		350		23					27	
	17	10.6		204		7					12	
	16U	10.2		1								
	16M	9.4		83		1					1	
	16L	8.5		165			20					
	15U	7.9		2			1					
	15M	7.4		3			5			1		1
	14	6.7		159		1						
	12	6.1		198			1					
	10U	5.2		576		2	1				13	
	10M	5.0		765		29					69	
	9	4.3		108		10					8	
	8	4.0					286			87		1
	7	3.4		20		2	22					
	5	2.5		3			52					
	4	2.1		144		2	2				1	
	2	1.5		120		4	178			18		
	1	0.8		2								
	0	-1.0	119			14					3	2
LOCALITY 2 (OSU SECTION 69SB)												
Ali Bashi	3	19.00		30	8	6					5	
	2	18.0		87*		4					5	
	1	17.0		57	30	12					19	
LOCALITY 4 (OSU SECTION 69SC)												
Ali Bashi	7U	16.4		225		10					10	
	7M	14.3		45		9					7	
	7L	13.0		122	4	35		2			16	1
	6	10.4		530		1					1	
	5	4.6		53		3		3		5	3	
	2	2.1		38		6					3	
	1	0.2		29				8		3		
OSU SAMPLE 67GH-28 (From interval 11.3 to 30.8 m above base Elikah Fm.)												
E.					1			1		11		29

[1] The numbers for units of the Ali Bashi Formation at Locality 1 correspond to those in the measured section on p. 374–381.

* Specimens with corrugated platform margins.

ments of this species cannot be enlarged from study of the 81 specimens at hand. These are clearly typical and are identified with *Anchignathodus isarcicus* without question. It should be noted only that Sweet (1970b) was obviously in error in removing to *A. typicalis* the laterally adenticulate specimens that Staesche (1964) assigned to *A. isarcicus*. Such elements do not occur with the few specimens of *A. isarcicus* known from Pakistan, but they are well represented in the Iranian collections under study (Pl. 11, fig. 5), and they are numerous in both Staesche's and Sweet's collections from the lower Werfen Formation of the southern Alps. These elements are shorter and broader than those of *A. typicalis*; have a high, almost straight posterior terminus; and tips of posterior denticles define a line that is not only normal to the axis of the cusp, but intersects it at midheight. These differences are well illustrated through comparison of figures 5 and 8 on Plate 11.

Kozur (1971) combines *Anchignathodus isarcicus* and *A. typicalis* Sweet into a single species, for which he uses the name *Spathognathodus isarcicus*. He gives no reasons for this combination, which results not only in considerably broadening the scope of a stratigraphically useful species but also seems to ignore distributional data summarized by Sweet (1970b) and increased in this report. Further, because the holotype of *Spathodus primus* Branson and Mehl, 1933, type species of *Spathognathodus*, was almost certainly part of the skeletal apparatus of the Silurian multielement species *Ozarkodina typica*, it seems curiously inexpressive of taxonomic relations to continue use of *Spathognathodus* for this Lower Triassic conodont species.

Occurence. Loc. 1, lower 4.5 m of Elikah Formation (OSU section 69SA), Kuh-e-Ali Bashi (Table 7); Kathwai Member, Mianwali Formation, Pakistan (Sweet, 1970b); lower Werfen Formation, northern Italy (Huckriede, 1958; Staesche, 1964).

Repository. Figured specimens, OSU 29551 (Pl. 11, fig. 5), 29552 (Pl. 11, fig. 6), 29553 (Pl. 11, fig. 7).

Anchignathodus julfensis n. sp.

Plate 11, figures 10–14

Diagnosis. A species of *Anchignathodus* characterized by straight to slightly bowed bladelike skeletal elements, about twice as long as wide, in which denticles in the posterior third of the unit produce a distinctive hump in the lateral profile.

Material. 568 discrete elements.

Description. Elements of *Anchignathodus julfensis* are bladelike units that are straight or slightly bowed and typically about twice as long as wide. At the anterior end of the unit is a laterally compressed cusp that is broadly triangular in lateral view; its axis is outlined by a strip of "white matter" along its posterior edge, which curves anteriorly and upward from the tip of the basal cavity. The anterior one-half to two-thirds of the cusp is a thin, flangelike process that lacks "white matter"; its anterior edge is sharp and smooth in most specimens, but marked by faint serrations anterobasally in a few. In a few large specimens the cusp tip is bifid; in smaller forms, however, it is single and sharply pointed.

Posterior to the cusp are 13 to 18 laterally compressed denticles of subequal width that are fused with adjacent denticles except at their tips, which are sharp in small elements, but bluntly rounded in larger ones. From a level slightly above the basal cavity to their tips, denticles are completely white at all stages in their growth.

The five to seven denticles just behind the cusp decline regularly in length, but in the posterior third of the unit denticle tips form an upwardly convex bulge or hump in the upper edge. In small elements representing early growth stages denticle tips in the "hump" are discrete; but in larger specimens, representing later growth stages, denticle tips fuse or are overgrown in at least the highest part of this segment of the element.

Beneath the posterior two-thirds of the element, the attachment surface is enclosed in a deep, asymmetrically subconical basal cavity, which is widest near its anterior end, tapers to a point at the posterior end of the unit, and is prolonged anteriorly as a low, narrow groove beneath the posterior half of the flangelike anterior extension of the cusp.

Remarks. The upwardly convex bulge or "hump" produced by denticles in the posterior third of the unit readily distinguishes elements of *Anchignathodus julfensis* from those of any previously described species of *Anchignathodus.* Except for this distinctive feature, *A. julfensis* elements are similar to those of both *A. typicalis* Sweet, type species of *Anchignathodus,* and *A. minutus* (Ellison), a common Carboniferous species. The sinuous lateral profile and the absence of lateral denticles, or of any discernible tendency to develop them, distinguish *A. julfensis* elements from those of *A. isarcicus* (Huckriede), a stratigraphically useful lowermost Triassic species.

Occurrence. Loc. 1, 1.5 to 8.5 m above the base of the Ali Bashi Formation, Kuh-e-Ali Bashi. (Samples 69SA-2, 4, 5, 7, 8, 10U, 12, 15M, 15U, and 16L.)

Repository. Syntypes, from sample 69SA-8, OSU 29554 (Pl. 11, fig. 10), 29555 (Pl. 11, fig. 11), 29556 (Pl. 11, fig. 12), 29557 (Pl. 11, fig. 13), 29558 (Pl. 11, fig. 14).

Anchignathodus typicalis Sweet?

Plate 11, figures 8, 9

?*Anchignathodus typicalis* Sweet, 1970a: 7, pl. 1, figs. 13, 22; Sweet, 1970b: 222–223, pl. 1, figs. 13, 20.

Our collections from the Julfa District contain 26 specimens that may represent *Anchignathodus typicalis* Sweet, but cannot be referred to that species with certainty either because they differ in some ways from typical representatives or because they are too fragmentary for positive identification. Two of the better-preserved specimens are illustrated and distribution of the others is given in Table 7.

The most characteristic feature of *Anchignathodus typicalis* elements is the profile of the upper edge of the denticle series, which forms a more or less straight line that declines regularly from the cusp tip to a point two or three denticles anterior of the posterior end of the unit. In addition, the posterior end of the unit curves abruptly downward, so that in the holotype it is essentially normal to the plane of the base. Elements here tentatively included in *A. typicalis* exhibit the profile distinctive of the holotype and lack the "hump" in the posterior part of that profile that is taken to be characteristic of *A. julfensis* elements. However, in a number of specimens, including the ones illustrated, abrupt rounding of posterior ends begins at a much higher level than in typical *A. typicalis* elements, with the result that the entire unit is somewhat shorter relative to its width than is true of the type material.

With respect to the morphology of its elements, *Anchignathodus typicalis* was undoubtedly a generalized form and it now seems likely that it was the stock from which several species having more distinctive elements developed. Our tentative identifications here may thus be susceptible of improvement in the future, when we have seen more material and can understand the phylogeny of *Anchignathodus* more fully.

Occurrence. Distribution of elements tentatively identified with *Anchignathodus typicalis* in Kuh-e-Ali Bashi is given in Table 7. The species is known from the uppermost Chhidru and lowermost Mianwali Formation of the Salt Range, West Pakistan (Sweet, 1970b); from the upper Zewan series and the lower few meters of the superjacent Lower Triassic beds at Guryul Ravine, Kashmir (Sweet, 1970a); from the *Otoceras-Ophiceras* beds of the Spiti District, western Himalayas (Sweet, unpublished MS); from Upper Permian and Lower Triassic strata in the Kap Stosch area of East Greenland (Sweet, unpublished MS); from the lower part of the Dinwoody Formation in Idaho and Wyoming (Sweet, 1970b and unpublished information); and from the lowest few meters of the Werfen Formation in the southern Alps of northern Italy (Sweet, 1970b).

Repository. Figured specimens, OSU 29559 (Pl. 11, fig. 8), 29560 (Pl. 11, fig. 9).

Genus *Ellisonia* Müller, 1956

Type species, *Ellisonia triassica* Müller, 1956

In a report on latest Permian and Early Triassic conodonts from Pakistan, Sweet (1970b) referred seven species based on recurrent groups of morphologically different elements to *Ellisonia* Müller. By referring these multielement species to *Ellisonia,* he indirectly expanded the scope of a genus originally erected to include only hibbardelliform conodont elements. No revised diagnosis was presented, however, for it was noted that a large number of conodont species, ranging in age from Ordovician through Triassic, had skeletal apparatuses composed of combinations of the forms that distinguish the multielement groups he assigned to *Ellisonia.* It is still not known how most of those species should be assembled into genera or what the names for those genera should be. *Ellisonia* was chosen primarily because the type of the form genus is Early Triassic in age and was probably a skeletal component of one of the species described. This essentially conservative procedure has drawn critical comment from Kozur and Mostler (1972a), however, and their views merit analysis.

On page 10 of their 1972a paper, Kozur and Mostler write:

> "In der sehr gewissenhaften und vorbildlichen Arbeit von HUDDLE 1968 wurde die Gattung *Ellisonia* als Synonym zu *Diplododella* gestellt. Die Typusart von *Ellisonia* und viele der dreiästigen Conodonten der Trias gehören zu *Diplododella.* Ein jüngeres Synonym muss aber verworfen werden; der Name *Ellisonia* kann also nicht verwendet werden."

This is a puzzling statement. The first sentence of it is correct; the second is a subjective assertion; and the last could be correct only if it were established that (1) Müller's original proposal of *Ellisonia* was defective in terms of the *International Code of Zoological Nomenclature,* and hence was invalid from the start; or that (2) the type species of *Diplododella* Bassler and *Ellisonia* Müller are founded on the same type specimen(s), and hence are objective synonyms.

In our opinion, *Ellisonia* is valid because Müller (1956) satisfied all of the provisions of the *International Code* in establishing it. That is, the name was published in the meaning of Chapters III and IV of the Code; it can be treated as a Latin word and as a noun in the nominative singular; Müller consistently applied binominal nomenclature in his paper; and proposal of the name was accompanied by a statement giving characters differentiating the taxon for which it was proposed. Further, Müller's original diagnosis of *Ellisonia* is accompanied by definite fixation of a type species, *Ellisonia triassica* Müller, 1956, which is founded on a discrete holotype from the Lower Triassic cephalopod bed, Dinner Springs Canyon, Nevada (Dept. Geol. Univ. Iowa, SUI 2257), that was also diagnosed and illustrated in Müller's 1956 report (p. 822, pl. 96, figs. 12–14).

By the same reasoning, *Diplododella* Bassler, 1925, is also valid. Its type species is *D. bilateralis* Bassler, 1925, which is based on a shale-embedded holotype (U. S. National Museum 11306 VP) from the Gassaway Member of the Chattanooga Shale of Alabama. Holotypes of *Ellisonia triassica* Müller, 1956, and *Diplododella bilateralis* Bassler, 1925, are clearly different specimens, of different ages, and from geographic localities more than 2,500 kilometers apart. There is not the remotest possibility that the two species, hence the genera of which they are types, are based on the same specimen, and Huddle (1968) makes no such claim.

In short, *Diplododella* Bassler, 1925, and *Ellisonia* Müller, 1956, are both valid generic names and they can not possibly be *objective* synonyms. All that Huddle did in his 1968 report was state the opinion that *Diplododella, Elsonella,* and *Ellisonia* are names for the same conodont form genus. In doing this, he proposed a *subjective* synonymy and chose *Diplododella* as the name for the combined form genus because it has obvious priority. Article 17(1) of the *International Code*, however, states that ". . . a name is or remains available even though . . . it becomes a junior synonym; such a name may be re-employed if the synonymy is judged to be erroneous, or if the senior synonym is found to be invalid or unavailable . . ." Thus, despite Huddle's action, *Ellisonia* is still available, and it will continue to be so until we either abandon binominal nomenclature or rewrite the *International Code.* Objectively and incontrovertibly, the name will always be available for use with the holotype of *E. triassica* Müller, 1956, which is type species of *Ellisonia.* Subjectively, the name is available for (but need not be used for) (1) any specimen identified as a representative of the same form species as the holotype of *E. triassica;* (2) any collection of specimens deemed to represent the multielement species of which the holotype of *E. triassica* is thought to have been a part; or (3) any form or multielement species thought to be part of the same genus as *E. triassica.*

Sweet (1970b) expressed the opinion that the holotype of *Ellisonia triassica* was part of a skeletal apparatus that also included the type specimens of *Hibbardella subsymmetrica* Müller, 1956; *Lonchodina triassica* Müller, 1956; *Hindeodella nevadensis* Müller, 1956, *H. triassica* Müller, 1956; *H. raridenticulata* Müller, 1956; *Neoprioniodus unicornis* Müller, 1956; and possibly the specimen Müller (1956) identified as *Ozarkodina?* sp. Because this array of elements includes one (*E. triassica*) that is type specimen of the type species of a genus (*Ellisonia*), Sweet chose, as first reviser, to use the name *Ellisonia triassica* for the species he thought was represented by the entire assembly just enumerated. Sweet's opinion may be unacceptable, but his procedures are permissible within the framework of the *International Code.* Actually, the only nomenclatural constraint introduced is upon those who agree with the Sweet opinion, for they must now use the trivial name *triassica* (rather than *subsymmetrica, nevadensis, raridenticulata,* or *unicornis*) for this multielement species.

The seven multielement species included in *Ellisonia* by Sweet (1970b) are similar in many ways, but they are by no means identical. In fact, three subgroups can be recognized. In one, including *E. triassica,* the hibbardelliform (or U-) element has a long, denticulated posterior process but there was apparently no enantiognathiform (or LC-) element; in another, including *E. teicherti,* the U-element lacks a posterior process and no enantiognathiform (or LC-) elements have been recognized; and in a third, including *E. clarki, E. delicatula, E. gradata,* and *E. torta,* enantiognathiform (=LC-) elements are prominent skeletal components and hibbardelliform (or U-) elements have denticulated posterior processes. If these differences are substantiated through study of additional material, they are probably sufficient to merit recognition of three genera. The name *Ellisonia* can be used appropriately for multielement species like the first one mentioned, but it is still not certain what names could (or should) be used for the other two groups. A likely candidate for the third group is *Cypridodella* Mosher, 1968, which is based on *C. conflexa* Mosher, 1968, a probable LA-element of a multielement apparatus generally like that of *Ellisonia gradata* Sweet, 1970a, 1970b. In this report, however, we continue to use *Ellisonia* for species of all three groups because their components are currently isolated from better-known Paleozoic faunas, interspecies relations are not clear, and there is some controversy as to the makeup of the apparatuses themselves.

Ellisonia gradata Sweet

Plate 12, figures 6–10

Ellisonia gradata Sweet, 1970a: 8, pl. 1, figs. 1, 5, 6, 9; Sweet, 1970b: 229–231, pl. 4, figs. 1–8.

Lonchodina latidentata (Tatge),-Huckriede, 1958: 151, pl. 10, figs. 32, 38, 39.

Roundya n. sp. A. Huckriede, 1958: 161, pl. 10, fig. 20.

Gen. et spec. indet. A. Huckriede, 1958: 163, pl. 10, fig. 28.

Collections from the Ali Bashi Formation in three sections in Kuh-e-Ali Bashi include 235 discrete elements that compare favorably with the syntypes of *Ellisonia gradata* Sweet and are assigned to that species without question. Sample-by-sample distribution and frequency of the five morphologically distinct components of *E. gradata* in Kuh-e-Ali Bashi collections are given in Table 8.

Except to extend the range of *Ellisonia gradata* downward into the uppermost Permian, and its geographic distribution to northwestern Iran, the material at hand adds little to the concept of the species as given by Sweet (1970a, 1970b), which was derived from a study of more than 1,000 discrete elements from Lower Triassic rocks in Kashmir and West Pakistan. Nevertheless, an extended discussion of *E. gradata* and its skeletal components is appropriate because questions about the species have been raised by Kozur and Mostler (1972a).

Kozur and Mostler (1972a: 10) have recorded their views as to identity of the syntypes of *E. gradata* (Sweet, 1970b, pl. 4, figs. 1–8) and those views are summarized and contrasted with Sweet's view in Table 9 of this report. After listing their views about *E. gradata*, Kozur and Mostler ask: "Why has a 'new species' been created here?" Moreover, they seem to be incredulous that "*Ellisonia gradata*," which is common in, and ranges through, the entire Scythian, has not been encountered by conodont workers before 1970 and that no individual element had been named before Sweet's (1970b) report appeared. Their conclusion, referring to views summarized in Table 9 but omitting mention of the U-element (OSU 28030), is that we here deal with no new form species but just with forms that were apparently unknown to Sweet even though they are among the commonest in the Triassic. That is, it is apparently their view that all the components of *E. gradata* (except its U-element) had already been named before 1970, but that Sweet was ignorant of this fact.

Table 8. Distribution and Frequency of Elements of *Ellisonia gradata* Sweet

Sample number	Frequency of element types: U	LA	LB1	LB2	LC
69SC-7U	3		2	1	4
69SC-7M	2	2			3
69SC-7L	3				13
69SC-6					1
69SC-5	1			2	
69SC-2	1				2
69SB-3	1		2		2
69SB-2	1		1		3
69SB-1	7	1	4	3	4
69SA-20M	3		1		3
69SA-20L	3	2	4	5	7
69SA-19L			1	1	1
69SA-18U			1		
69SA-18L		6	9	1	11
69SA-17	4	1	1	1	5
69SA-16M					1
69SA-10U	5			1	7
69SA-10M	11	7	16	4	31
69SA-9	3	1		1	3
69SA-4					1

Contrary to this opinion, all the form species mentioned by Kozur and Mostler as senior synonyms for the various skeletal components of *Ellisonia gradata* were well known to Sweet before he proposed names for any of the multielement species in his reports on conodonts from Kashmir and Pakistan. In June 1966, Sweet compared all components of *E. gradata* directly with type and other relevant specimens in the Tatge and Huckriede collections in Marburg, and in the Staesche collections in Tübingen. He has not seen the type material of *Apatognathus ziegleri* Diebel, which is housed in Berlin. From those comparisons, Sweet concluded that, in spite of obvious similarities in overall organization and structure, material from Pakistan differed systematically from, and therefore did not represent any of, the form species founded on type material housed in the Marburg or Tübingen collections. He also concluded, as stated in the synonymy on page 229 of his 1970b report, that U-elements of *E. gradata* are the same as the Salt Range Triassic specimens Huckriede (1958) described as *Roundya* n. sp. A; and that LB2-elements of *E. gradata* were clearly the same as the Salt Range specimens assigned to *Lonchodina latiden-*

TABLE 9. IDENTITY OF SYNTYPES OF *Ellisonia gradata* ACCORDING TO SWEET (1970b) AND KOZUR AND MOSTLER (1972a)

Syntypes	Identified by Sweet as	by Kozur and Mostler as
OSU 28027	LC-element, *E. gradata*	Fragment of an undoubted *Enantiognathus ziegleri* (Diebel, 1956).
OSU 28028	LB1-element, *E. gradata*	*Hindeodella* (*Metaprioniodus*) *suevica* (Tatge, 1956) emend. Kozur & Mostler (=*Hindeodella* (*Metaprioniodus*) *latidentata latidentata* (Tatge) *sensu* Kozur, 1968).
OSU 28029	LA-element, *E. gradata*	*Prioniodina* (*Cypridodella*) *muelleri* (Tatge, 1956); anterior process fragmentary; of the type of *Prioniodina mediocris* (Tatge) of Huckriede (1958).
OSU 28030	U-element, *E. gradata*	*Hibbardella* sp.; probably a new form species; preservation too bad to permit statements about it; probably identical with *Roundya* n. sp. A. Huckriede, 1958 and *Hibbardella nevadensis* (Müller) of Igo and Koike, *in* Igo, Koike, and Yin, 1965.
OSU 28031	LA-element, *E. gradata*	*Prioniodina* (*Cypridodella*) *muelleri* (Tatge, 1956); anterior process fragmentarily preserved.
OSU 28032	LB1-element, *E. gradata*	So fragmentary that no assignment to a certain form species is possible (possibly *Hindeodella* (*Metaprioniodus*) *suevica*).
OSU 28033	LB2-element, *E. gradata*	*Hindeodella* (*Metaprioniodus*) *suevica*; very fragmentary; posterior process broken off; form with forked anterior end.

tata (Tatge) by Huckriede (1958)—but not the same as the type specimen of *Prioniodina latidentata* Tatge, 1956. Kozur and Mostler seem to have overlooked this, and in forming their conclusions about Sweet's lack of familiarity with the form species they cite, they also contradict one of their own dicta (1972a: 9–10), which states: ". . . wir möchten nicht in den Fehler einiger Autoren verfallen, die nicht aufgeführte Untersuchungen als nicht vorhandene Untersuchungen werten . . ."

What then, is the problem with *Ellisonia gradata*? Apparently there are two problems. First, Sweet has adopted multielement taxonomy as a *modus operandi* in conodont studies; and second, he apparently permitted considerably less variation from the stratigraphic and morphologic norms set by type specimens than did Kozur and Mostler. As to the first problem, Sweet notes that he is far more concerned with identifying and determining the distributions of recurrent groups of conodont elements that exhibit similarities in structural and secondary morphologic details than with establishing either the distribution or morphologic limits of the form species to which components of these groups might be assigned by practitioners of form taxonomy. In brief, Sweet regards the recurrent group as the basis for founding a conodont species, not the components (= form species) of that group, for at least some of the latter may be generalized forms that occur in several groups. Trivial names for these multielement species must be those of their oldest-named components only if it can be established that types of those form species were also parts of the recurrent groups for which their names are to be used.

But Kozur and Mostler are not inexperienced in multielement taxonomy. Indeed, in their 1971 paper they provide a good answer to the question they posed later (Kozur and Mostler, 1972a) about the need to name *Ellisonia gradata*. That is, in the former paper they established a "multielement" named "*Enantiognathus ziegleri,*" which includes components previously referred to the form species *Hibbardella magnidentata* (including "*Prioniodella*" *prioniodellides*) (= U-element), *Prioniodina muelleri* (= LA-element), *Hindeodella* (*Metaprioniodus*) *suevica* (= LB1- and LB2-elements), *Enantiognathus ziegleri* (= LC-element), and *Ozarkodina tortilis* (= ?-element). Except for *O. tortilis,* whose association with the "*E. ziegleri*" multielement is questioned by Kozur and Mostler themselves, this is the same array of element types assigned by Sweet (1970b) to the multielement species *Ellisonia gradata, E. clarki, E. delicatula, E. robusta,* and *E. torta.* Indeed, except for *Ozarkodina tortilis* and the U-element, this is the same list of form species to which Kozur and Mostler (1972a) assign the components of multielement *E. gradata* Sweet (cf. Table 9).

Sweet agrees that "*Enantiognathus ziegleri*" *sensu* Kozur and Mostler, 1971, (minus the problematic *Ozarkodina tortilis*) is a likely multielement species and comments only that it probably belongs in the same genus as *Ellisonia gradata.* Whether the Kozur-Mostler multielement species should be named "*Enantiognathus ziegleri*" or not is quite a different matter. That is, until it is known what other elements are associated with the type specimen of *Apatognathus ziegleri* Diebel, 1956, it would seem far safer to choose a name for the Kozur-Mostler multielement species from among the form species Tatge (1956) named *Roundya magnidentata, Lonchodina muelleri, Apatognathus longidentatus,* and *Prioniodina latidentata,* for the holotypes of all these are from the same sample and there can be little doubt about their co-occurrence or identity in age.

What is especially significant to this discussion is the fact, admitted by Kozur and Mostler (1972a), that the U-elements of *Ellisonia gradata* and "*Enantiognathus ziegleri*" are different. In all of the 156 U-elements of *E. gradata in* Sweet's collections from the Salt Range, West Pakistan, and from Kuh-e-Ali Bashi, Iran, the cusp is at the crest of the anterior arch, is several times longer than any preserved denticle posterior of it, and is not preceded in any specimen by anterior denticles of any size. On the holotype of *Roundya magnidentata,* the U-element of "*Enantiognathus ziegleri,*" however, there is a denticle anterior of the cusp, and Kozur and Mostler (1972b) state that in this form species there are generally one to two small denticles between the cusp and the crest of the anterior arch. Other differences, perhaps of lesser importance, are readily discernible by comparing Sweet's (1970b) description and illustration of the syntype U-element of *E. gradata* with Tatge's (1956) illustration and description of the holotype of *Roundya magnidentata* and Kozur and Mostler's (1972b) description and illustrations of specimens they identify with the form species.

According to Kozur and Mostler (1972a; Table 9 of this report), all the syntype LB1- and LB2-elements of *Ellisonia gradata* are fragmentary representatives of *Hindeodella* (*Metaprioniodus*) *suevica* (Tatge), in which they also include *Prioniodina latidentata* Tatge and the conodonts distributed by 12 previous authors among some 18 different form species (Kozur and Mostler, 1972b). Sweet has re-examined the 268 questioned specimens from the Lower Triassic of Pakistan and has given careful attention to 57 additional ones from Kuh-e-Ali Bashi collections. All these specimens are fragmentary in one way or another. Most lack a denticle- or cusp-tip here and there and all lack an unknown length of the posterior process. Nevertheless, in a substantial number enough of that process is preserved to show that its lower margin is quite straight in lateral view, not bowed downward a short distance behind the cusp as in the holotype of *Lonchodina suevica* Tatge and in all the complete representatives of this form species illustrated by Kozur and Mostler (1972b, pl. 9, figs. 20, 22, 23). On a few tiny specimens, the posterior process, although truncated by breakage, is so low at its distal end that it is difficult to believe it could ever have been as long as, to as much as three times as long as, the anterior process. Further, denticles on both anterior and posterior processes are distinctly compressed and bladelike, not of circular cross section as are the denticles and cusp of the holotype; and the cusp of elements representing late growth stages is broadly triangular in lateral view and can be seen to have incorporated in its basal portion denticles that were adjacent to it laterally at earlier stages in growth. None of these features was mentioned by Tatge (1956) as a character of the two specimens on which she based her concept of *Lonchodina suevica* and none was apparent to Sweet when he examined those specimens in Marburg. Finally, LB- elements of *Ellisonia gradata,* like other skeletal components of this species, are distinguished from the holotype of *L. suevica* by a cloudy distribution of "white matter." Kozur and Mostler (1972a) minimize the taxonomic significance of "white-matter" by appeal to an unsupported assertion that this feature (and others such as robustness and, to some extent, the degree of fusion and the number and development of the denticles) is dependent on facies conditions such as water depth and water movement. This may well be so, but the fact remains that all the features mentioned, including "white-matter" distribution, are objective characters and, as such, they are commonly used to distinguish one specimen from another.

What about *Ellisonia gradata,* then? As conceived by Sweet (1970a, 1970b), it is a multielement species, based on an assemblage of conodont elements, which forms a recurrent group with an average Index of Affinity of 0.77 in collections from Lower Triassic rocks in West Pakistan. Based on the 24 Pakistan samples that contain all the elements of this recurrent group, the coefficient of rank concordance is 0.41, and this value is statistically significant at the 0.05 level. Further, components of this group are intergradational morphologically and similar in style of denticulation, conformation of attachment surface, size, and distribution of "white matter." In fact, the group meets all the criteria Sweet and his colleagues have set for themselves in recognizing multielement species (Webers, Schopf and Sweet, 1966; Bergström and Sweet, 1966; Kohut and Sweet, 1968; Sweet and Bergström, 1970; Sweet, 1970b; etc.). Kozur and Mostler (1972a) do not question the concept of *E. gradata,* which closely matches that of their "*Enantiognathus ziegleri,*" so they must be worried about the name proposed for *E. gradata,* not about the species itself.

Sweet has tried to show that there are objective differences between the U- and LB-elements of *Ellisonia gradata* and the holotypes of *Roundya magnidentata* Tatge and *Lonchodina suevica* Tatge. Comparable differences could be cited if additional space were devoted to comparing the LA-elements of *E. gradata* with the type of *Lonchodina muelleri* Tatge. However, even if one were to accept all the synonymies suggested by Kozur and Mostler for the components of *E. gradata,* the hibbardelliform U-element would still be unassociated with a previously named form species. And this, in Sweet's opinion, is sufficient to distinguish the recurrent group he named *Ellisonia gradata* from "*Enantiognathus ziegleri*" of Kozur and Mostler (1971), which may well include the type specimens of all the form species but *Apatognathus ziegleri* to which those authors referred the syntypes of *E. gradata.*

Occurrence. Loc. 1, 1.0 m below base of Ali Bashi Formation, and Ali Bashi Formation, Kuh-e-Ali Bashi, Iran (Table 7); base to top of Mianwali Formation (Lower Triassic), Salt Range, West Pakistan (Sweet, 1970b); Lower Triassic strata, Guryul Ravine, Kashmir (Sweet, 1970a).

Repository. Figured hypotypes, OSU 29561 (Pl. 12, fig. 8), 29562 (Pl. 12, fig. 10), 29563 (Pl. 12, fig. 9), 29564 (Pl. 12, fig. 6), 29565 (Pl. 12, fig. 7).

Ellisonia teicherti Sweet
Plate 12, figures 1–5

Ellisonia teicherti Sweet, 1970a: 8, pl. 1, figs. 3, 4, 7, 8, 12; Sweet, 1970b: 232–234, pl. 4, figs. 20–28.

This distinctive multielement species is represented in the collections at hand by the 159 discrete elements whose distribution and frequency are given in Tables 7 and 10. In general, representatives of *Ellisonia teicherti* in Kuh-e-Ali Bashi collections are somewhat smaller than the syntypes of the species, which are from Lower Triassic rocks in Pakistan. In all other respects, however, they are comparable and are assigned to the species without question.

As noted in the original diagnosis of *Ellisonia teicherti* (Sweet, 1970a, 1970b) the uniform distribution of "white matter" throughout all elements is a distinctive character of the syntypes of this species, and it is equally evident in the specimens at hand. We also have pointed out in the discussion of *Ellisonia* earlier in this report that U-elements of multielement *E. teicherti* lack a posterior process and that the species thus differs from multielement *E. triassica*, whose hibbardelliform U-elements have a long, denticulated posterior process. This difference may ultimately be judged to be of generic significance when more is known of the distribution of *E. teicherti* and related species.

Occurrence. Ali Bashi and lower Elikah formations, Kuh-e-Ali Bashi, Iran (Tables 7, 10); uppermost Chhidru and lowermost Mianwali Formation, Salt Range, West Pakistan (Sweet, 1970b); uppermost Zewan series and lower part of superjacent Lower Triassic strata, Guryul Ravine, Kashmir (Sweet, 1970a); Upper Permian and Lower Triassic strata, Kap Stosch area, East Greenland (Sweet, unpublished MS); lower Dinwoody Formation at Teton Pass, Wyoming (Sweet, unpublished MS).

Repository. Figured hypotypes, OSU 29566 (Pl. 12, fig. 5), 29567 (Pl. 12, fig. 2), 29568 (Pl. 12, fig. 1), 29569 (Pl. 12, fig. 3), 29570 (Pl. 12, fig. 4).

Table 10. Distribution and Frequency of Elements of *Ellisonia teicherti*

Sample No.	Frequency of Element Types U	LA	LB	LD	LE
Loc. 4					
69SC-5		1	2	1	1
69SC-1			1		2
Loc. 1					
69SA-C3		1			
69SA-C1		3			1
69SA-22U		3	3		
69SA-22M	1	1	10	4	5
69SA-20U				2	
69SA-15M				1	
69SA-8	2	14	39	12	20
69SA-2	4	2	5	4	3
67GH-28	1	4	4	1	1

Ellisonia spp.

Our collections from Kuh-e-Ali Bashi include 47 specimens that almost certainly represent skeletal components of some species of *Ellisonia* as that genus is defined in this report. A majority of the specimens are fragmentary and most of them are substantially larger than the ones assigned to either *E. gradata* or *E. teicherti*. It is likely that many, if not all, of these specimens are assignable to *E. triassica*, but we make no such assignment because the few identifiable specimens we have occur in different samples, not in association.

Occurrence. Distribution and frequency of specimens identified as *Ellisonia* spp. are given in Table 7.

Genus *Neogondolella* Bender and Stoppel, 1965

Type species, *Gondolella mombergensis* Tatge, 1956

The concept of this conodont genus employed here is the same as that outlined by Sweet (1970b). Clark and Mosher (1966) have described features that distinguish groups of Pennsylvanian, Permian, and Triassic species referred by most previous authors to *Gondolella*, and Sweet (1970b) has noted that *Neogondolella* elements differ from those of typical *Gondolella* in being finely to coarsely pitted (rather than smooth and glassy) on their upper sides; and in having a platform that is continued around the posterior side of the cusp as a more or less pronounced brim, whereas in typical

Gondolella elements, lateral platform elements are continuous with well-defined costae on the sides of the terminal cusp. Because relationships between Carboniferous and Permian-Triassic conodonts with gondolelliform elements are still obscure, it seems better to emphasize differences by referring the two types to separate genera than to unite all these forms in a single genus, *Gondolella.*

Gondolelliform elements dominate our collections from 1 m below the Ali Bashi Formation and from the superjacent Ali Bashi Formation. *Ellisonia gradata* Sweet and *Xaniognathus* cf. *X. elongatus* Sweet are common associates, but there is little in the way of morphologic similarity or frequency-ratios to suggest that all these elements were once parts of the same skeletal apparatus. Instead, we regard the gondolelliform elements at hand as representatives of two single-element species, *Neogondolella orientalis* (Barskov and Koroleva) and *N. carinata* (Clark). Among elements assigned to the latter, we recognize three intergradational subgroups, which are described formally as two subspecies of *N. carinata.*

Neogondolella carinata (Clark)

Gondolella carinata Clark, 1959: 309, pl. 44, figs. 15–19.

Neogondolella carinata (Clark),–Sweet, 1970b: 240, pl. 3, figs. 1–17, 24, 26, 27.

More than 75 percent of the conodont elements in collections from the Ali Bashi Formation are referable to *Neogondolella.* A few of these (102) are clearly identifiable with *N. carinata* (Clark), but the majority are intermediate morphologically between typical *N. carinata* and *N. orientalis* (Barskov and Koroleva), which are abundantly represented in the beds immediately below the Ali Bashi Formation. Because characters that distinguish most specimens of the Ali Bashi *Neogondolella* are constant through the formation, we believe the taxon merits separate recognition. However, because the elements at hand exhibit posterior characters more like those of *N. carinata* than of *N. orientalis,* we describe them here as representatives of a new subspecies of *N. carinata, N. carinata subcarinata.* A third group of gondolelliform elements, all from sample 69SB-2, is apparently related to the one we describe as *N. carinata subcarinata,* but platform margins are distinctly corrugated. We include these tentatively in *N. carinata subcarinata,* although in the future they may deserve separate identity as a subspecies of *N. carinata* or as an independent species of *Neogondolella.*

Neogondolella carinata carinata (Clark)

Plate 11, figures 1–4; Text-figure 16, I–L

(See synonymy for the species)

Elements of the typical subspecies of *Neogondolella carinata* (Clark) are distinguished by a spoutlike buttress at the posterior end which develops ontogenetically as the posterior ends of lateral platform segments grow around the cusp. Straight elements are essentially bilaterally symmetrical and, in superior view, the posterior platform buttress is set off by distinct notches in the platform margin just anterior to the cusp. Bowed elements lack an obvious notch on their convex side, particularly if they represent late growth stages, but retain a deep invagination in the platform margin on the concave side. In very large specimens the diagnostic platform notches tend to disappear or to be greatly subdued by continued growth of the posterior platform segment.

Occurrence. Locs. 1, 2, and 4, upper part of Ali Bashi Formation (at or near base of that part of the Ali Bashi Formation termed Paratirolites limestone by Stepanov *et al.*, 1969), and in sample 67GH-28 from between 11.3 and 30.8 m above the base of the Elikah Formation, Kuh-e-Ali Bashi, Iran (Table 7); uppermost part of Chhidru Formation (Permian) and lower part of superjacent Mianwali Formation (Lower Triassic), Pakistan (Sweet, 1970b); 33 to 55 feet above base of Triassic, Guryul Ravine, Kashmir (Sweet, 1970a); pre-*Meekoceras* Zone Triassic beds, Nevada (Clark and Mosher, 1966); uppermost Permian and

Lower Triassic strata, Kap Stosch region, East Greenland (Sweet, unpublished MS).

Repository. Figured specimens, OSU 29571 (Pl. 11, figs. 1, 3), 29572 (Pl. 11, figs. 2, 4).

Neogondolella carinata subcarinata Sweet n. subsp.

Plate 13, figures 12–17; Text-figure 16E–H

Diagnosis. A subspecies of *Neogondolella carinata* (Clark) with elements distinguished from those of the typical subspecies by a somewhat broader platform; a shorter, wider keel; and a less distinctly set-off buttress beneath the posterior platform brim.

Description. Elements of *Neogondolella carinata subcarinata* are symmetrical to slightly asymmetrical, 2.2 to somewhat less than 3 times as long as wide, and lachrymiform in outline. The carina is laterally compressed, straight or slightly bowed, and composed of seven to as many as 18 denticles, which are discrete in small specimens but fused, except at their tips, in larger ones. In elements representing intermediate and late growth stages, denticles in the middle third of the carina tend to form a low ridge, or are overgrown almost to their apexes by the platform. At both ends of the carina are distinctive crests of denticles: a posterior set of two or three includes the cusp, which is strongly inclined posteriorly; an anterior set of four to six surmounts a fragile bladelike extension of the carina.

Even in the smallest specimens available (Text-fig. 16, E), the carina is completely surrounded by a platform. The posterior extension of the platform is continuous with the posterior margin of the cusp and can be seen from below to be the upper edge of a faint spoutlike buttress, which, in small specimens, is more distinctly set-off from the remainder of the platform than in larger ones.

The under surface bears a narrow median groove, which is continuous with a slightly expanded, elongate pit beneath the cusp. Bordering the groove and pit and forming a very narrow band around the posterior end of the pit, is a well-marked keel, the under surface of which is flat or slightly convex. In none of our specimens is the keel more than half as wide as the unit; in most it is no wider than a fourth to a third the width of the platform.

Discussion. Elements of *Neogondolella carinata subcarinata* are readily distinguished from those of *N. orientalis* (Barskov and Koroleva) by presence of a distinct cusp at the posterior end of the unit at all stages of growth, by the very narrow posterior platform brim, and by the relatively narrow keel. Elements of this new subspecies are distinguished from those of *N. carinata carinata* by the indistinct posterior platform buttress and by lack of the distinct notches that mark the points in *N. carinata carinata* elements where lateral and posterior platform brims join around the cusp.

Occurrence. Ali Bashi Formation, Locs. 1, 2, 4, Kuh-e-Ali Bashi, Iran (see Table 7 for distribution and frequency).

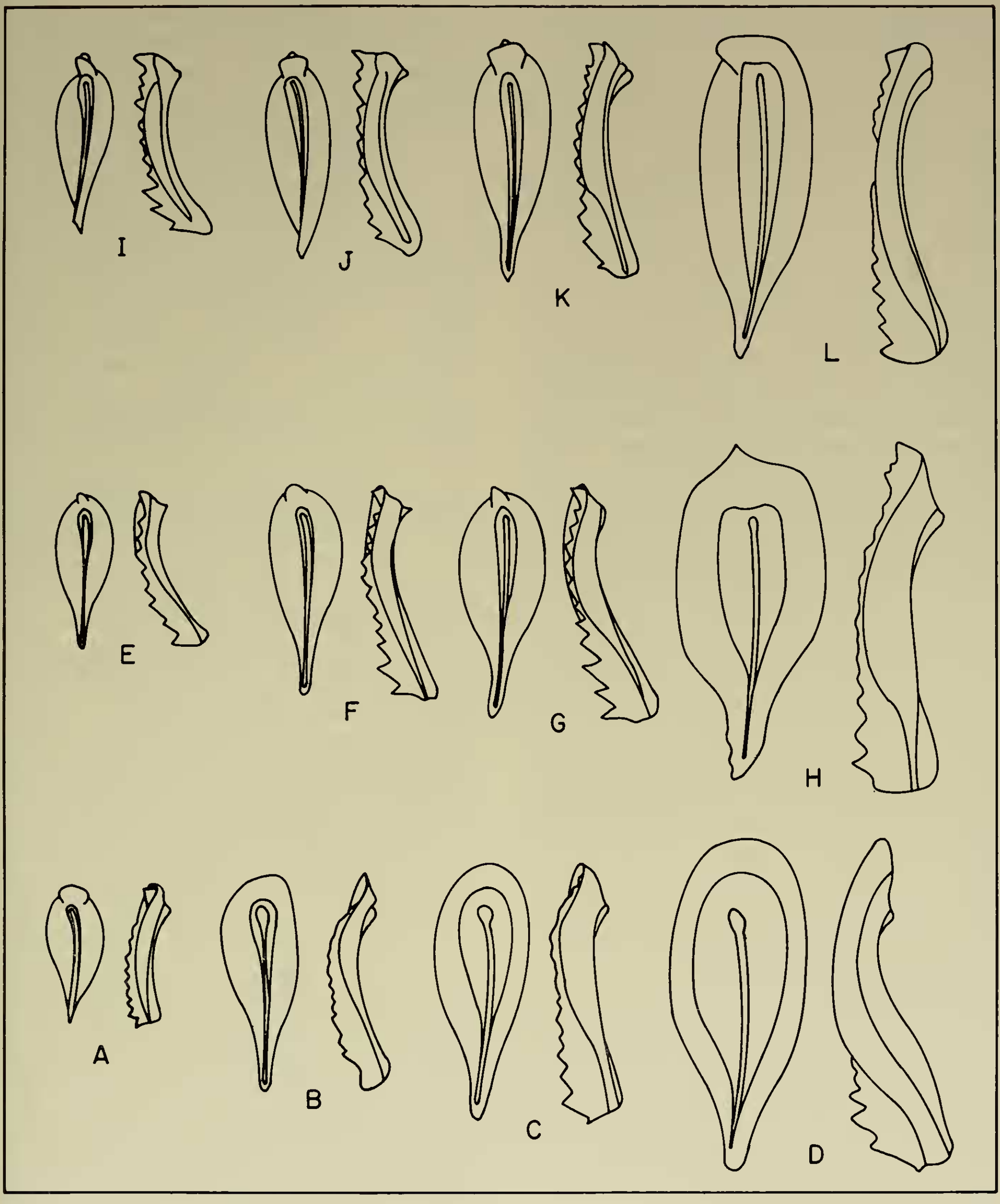
Repository. Syntypes, OSU 29573 (Pl. 13, figs. 12, 13), 29574 (Pl. 13, figs. 14, 15), 29575 (Pl. 13, figs. 16, 17).

Neogondolella carinata subcarinata Sweet, n. subsp. ?

Plate 13, figures 1–3

From a single sample (69SB-2) taken from about 1 m above the base of the Paratirolites limestone in the upper part of the Ali Bashi Formation, we have 87 gondolelliform elements that may be variants of *Neogondolella carinata subcarinata* or may represent a taxon that merits separate identity. We associate these specimens tentatively with *N. carinata subcarinata* because they exhibit some of the characters of elements of that subspecies, occur within the upper part of its range, and are known from just a single sample.

The elements in question are similar to those of *Neogondolella carinata subcarinata* in features of the lower surface and are in possession of a distinct posterior cusp, which is enclosed by an indistinct platform buttress. At the same time, they differ from those of *N. carinata subcarinata* in develop-



Text-figure 16. Outline of under and lateral views, ×50, of 12 specimens representing successive growth stages of (A–D) *Neogondolella orientalis* (Barskov and Koroleva), (E–H), *Neogondolella carinata subcarinata*, n. subsp., and (I–L) *Neogondolella carinata carinata* (Clark). Originals of views A–D are from *Vedioceras* beds, Dorasham 2 section, Nakhichevan ASSR; views E–H represent four of the syntypes of *N. carinata subcarinata;* and views I–L are of specimens from the Kathwai Member of the Mianwali Formation, Salt Range, Pakistan.

ment of transverse corrugations or crenulations along the lateral platform margins. These corrugations are only faintly discernible in small elements (Pl. 13, fig. 2), but increase in prominence in larger ones (Pl. 13, figs. 1, 3).

Occurrence. Sample 69SB-2, Loc. 2, 18 m above base of Ali Bashi Formation, Kuh-e-Ali Bashi, Iran.

Repository. Figured specimens, OSU 29585 (Pl. 13, fig. 1), 29586 (Pl. 13, fig. 2), 29587 (Pl. 13, fig. 3).

Neogondolella orientalis (Barskov and Koroleva)

Plate 13, figures 4–11; Text-figure 16A–D

Gondolella orientalis Barskov and Koroleva, 1970: 933, fig. 1, 1–4.

Barskov and Koroleva (1970) assigned some 150 specimens from the middle part of the Dzhulfian *Vedioceras* beds of the Dorasham 2 section in Transcaucasia to this distinctive species, and we have an additional 119 specimens from a stratigraphically comparable level in Kuh-e-Ali Bashi that are clearly conspecific. Although all of the specimens illustrated by Barskov and Koroleva lack part or all of the anterior end, the diagnosis and description prepared from a study of these specimens are thorough and more than adequate for recognition of the species.

Elements of *Neogondolella orientalis* are bilaterally symmetrical to weakly asymmetrical, lachrymiform in outline, and prominently arched in the posterior third of their length. In elements representing the earliest growth stages recognized in our collections, the carina is laterally compressed and consists of seven to nine apically discrete denticles of essentially the same length. In elements representing successively later stages of growth, the anterior three to five denticles become progressively more prominent, whereas those in the middle third of the carina fuse laterally to form a ridge that declines in height posteriorly and loses its identity at a point well anterior of the posterior margin of the element.

In elements representing all of the growth stages available to us, the carina is completely surrounded by a scoop-shaped platform having a finely pitted upper surface, which is broadly concave transversely, rounded posteriorly, widest at element midlength, and gradually tapered to the extremity of the element in the anterior third of its length. In the smallest element in our collection (Text-fig. 16, A), a prominent denticle at the posterior end of the carina, the cusp, is separated from the posterior margin of the element by a narrow platform brim, which can be seen from the under side to be the upper edge of a rounded buttress at the posterior end of the platform. In successively larger elements, the buttress disappears and the posterior platform brim broadens, in part through incorporation of the cusp, which is not a prominent feature, or may even be completely overgrown, in elements representing later growth stages.

The undersurface is distinguished by a narrow median furrow that terminates posteriorly in an elongate pit beneath the cusp. In elements representing early growth stages, the pit and furrow are enclosed laterally by a thin-walled sheath, which forms a median ridge on the under surface. In successively larger elements the pit and furrow come to be surrounded by a progressively wider and longer keel, the flat to faintly concave undersurface of which is marked by closely spaced longitudinal striae that represent the edges of growth lamellae. In specimens representing intermediate and late growth stages, the keel occupies one-half to as much as two-thirds the width of the undersurface.

Discussion. Elements of *Neogondolella orientalis* are distinguished from those of *N. carinata carinata* (Clark) by the lack of a prominent cusp except in early growth-stage elements, by the broad posterior platform brim, and by a keel that is one-half to two-thirds as wide as the unit in elements that represent intermediate and late growth stages. However, elements typical of *N. orientalis* grade through elements here assigned to *N. carinata subcarinata* Sweet, n. subsp., into elements referable to *N. carinata carinata* in all of the features just mentioned. Indeed, it appears from evidence now available that features seen only in early growth-stage elements of *N. orientalis* are prolonged into successively later growth stages in *N. carinata subcarinata* and *N.*

carinata carinata. From this we conclude that *N. carinata* evolved from *N. orientalis* in the latest Permian, and that linkage in this suggested series is provided by forms from the Ali Bashi Formation of Iran that we refer to *N. carinata subcarinata*.

Occurrence. Sample 69SA–0, Loc. 1, from beds 1 m below the base of the Ali Bashi Formation, Kuh-e-Ali Bashi, Iran; mid-portion of *Vedioceras* beds, Dorasham 2 area, Nakhichevan ASSR (Barskov and Koroleva, 1970).

Repository. Figured hypotypes, OSU 29576 (Pl. 13, figs. 10, 11), 29577 (Pl. 13, figs. 4, 5), 29578 (Pl. 13, figs. 8, 9), 29579 (Pl. 13, figs. 6, 7).

Genus *Xaniognathus* Sweet, 1970

Type species, *Xaniognathus curvatus* Sweet, 1970

Xaniognathus was erected (Sweet, 1970b) to include conodont species with skeletal apparatuses consisting of elements of a single morphologic type. In conventional parlance, these are ozarkodiniform elements with a long, denticulated anterior process that is longitudinally ribbed at mid-height, and a shorter posterior process that bears no midlateral rib.

Xaniognathus sp. cf. *X. elongatus* Sweet

Plate 12, figures 11–15

cf. *Xaniognathus elongatus* Sweet, 1970b: 266, 268, pl. 3, fig. 19.

Our collections from Kuh-e-Ali Bashi contain 219 representatives of *Xaniognathus* that are closely similar in a majority of their comparable characters to elements from the upper part of the Lower Triassic on which Sweet (1970b) based *Xaniognathus elongatus*. The elements at hand are largely from Permian rocks, however, and collectively they differ in at least two ways from the holotype and its companions on which the concept of *X. elongatus* was based. We do not know at this time whether greatest taxonomic weight should be placed on the many similarities, or on the differences between the Iranian Permian specimens and typical *X. elongatus* elements. Hence we describe the specimens at hand in open nomenclature, but indicate their close morphologic relationship to *X. elongatus* by comparing them with that species.

Iranian specimens compared with *Xaniognathus elongatus* are all arched and bowed ozarkodiniform elements, with a long, straight posterior process that is stout but not distinctly ribbed longitudinally; a steeply reclined, laterally compressed, sharp-edged cusp; and a short posterior process, which is thin, fragile, and no more than half as long as the anterior process. The eight to ten denticles of the anterior process, and the three to five of the posterior process, are sharply pointed, compressed, discrete for at least half their length, and steeply and uniformly reclined with respect to the axes of their respective processes. In lateral profile, the lower edge of the unit is almost straight in some elements (Pl. 12, fig. 15), but distinctly arched in others (Pl. 12, figs. 11–14); in elements of both types, however, there is a short downwardly convex segment in the lower margin just behind the posterior edge of the basal pit. Beneath the cusp is a sharp-pointed basal pit, which projects upward into the blade for about half its height but does not flare noticeably laterally. The pit is prolonged as a shallow groove beneath the proximal third of both processes; the underedge of the balance of the processes is sharp or faintly rounded. In elements that apparently represent later stages of growth, the attachment surface is distinctly "inverted" for essentially its entire length and, in a number of specimens, a narrow, sharp-edged ridge parallel to, but somewhat above, the lower margin, marks the upper edge of the "inverted" base.

In most specimens, the blade is clear and transparent below the level of denticle bases, and denticles and cusp are uniformly, but not densely, white. A few specimens, however, exhibit a slightly irregular distribution of "white matter" in denticles and cusp, and in this respect they somewhat resemble elements of *Ellisonia gradata*.

Remarks. The elements here compared

with *Xaniognathus elongatus* differ from typical representatives of that species in lacking a distinct midlateral rib on the stout anterior process and in having an attachment surface that is "inverted" for essentially its full length (rather than just posteriorly) in late growth-stage forms. It should be noted, however, that Iranian specimens are mostly much larger than typical *X. elongatus* elements from Pakistan and the differences just mentioned could well be associated with size and stage of growth represented.

The elements at hand, like the type material of *Xaniognathus elongatus,* are also similar in many ways to elements of *"Ozarkodina" tortilis* Tatge, but the posterior process of the latter is prominently twisted and nearly as long as the anterior process. Furthermore, in none of the descriptions of *"Ozarkodina" tortilis* elements is "inversion" of the attachment surface mentioned as a distinctive character.

Occurrence. Distribution and frequency in the Kuh-e-Ali Bashi samples are summarized in Table 7.

Repository. Figured specimens, OSU 29580 (Pl. 12, fig. 11), 29581 (Pl. 12, fig. 12), 29582 (Pl. 12, fig. 13), 29583 (Pl. 12, fig. 14), 29584 (Pl. 12, fig. 15).

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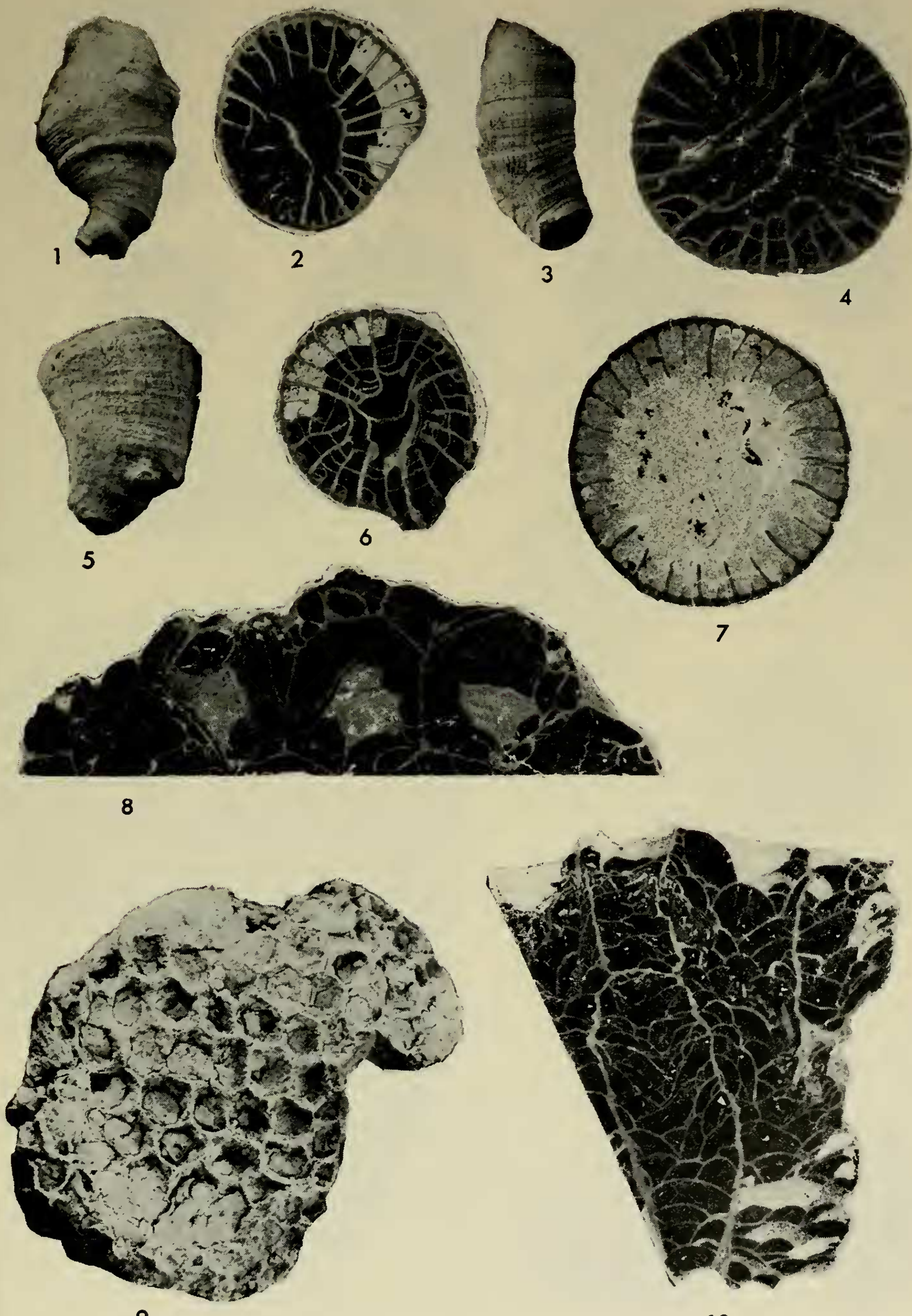
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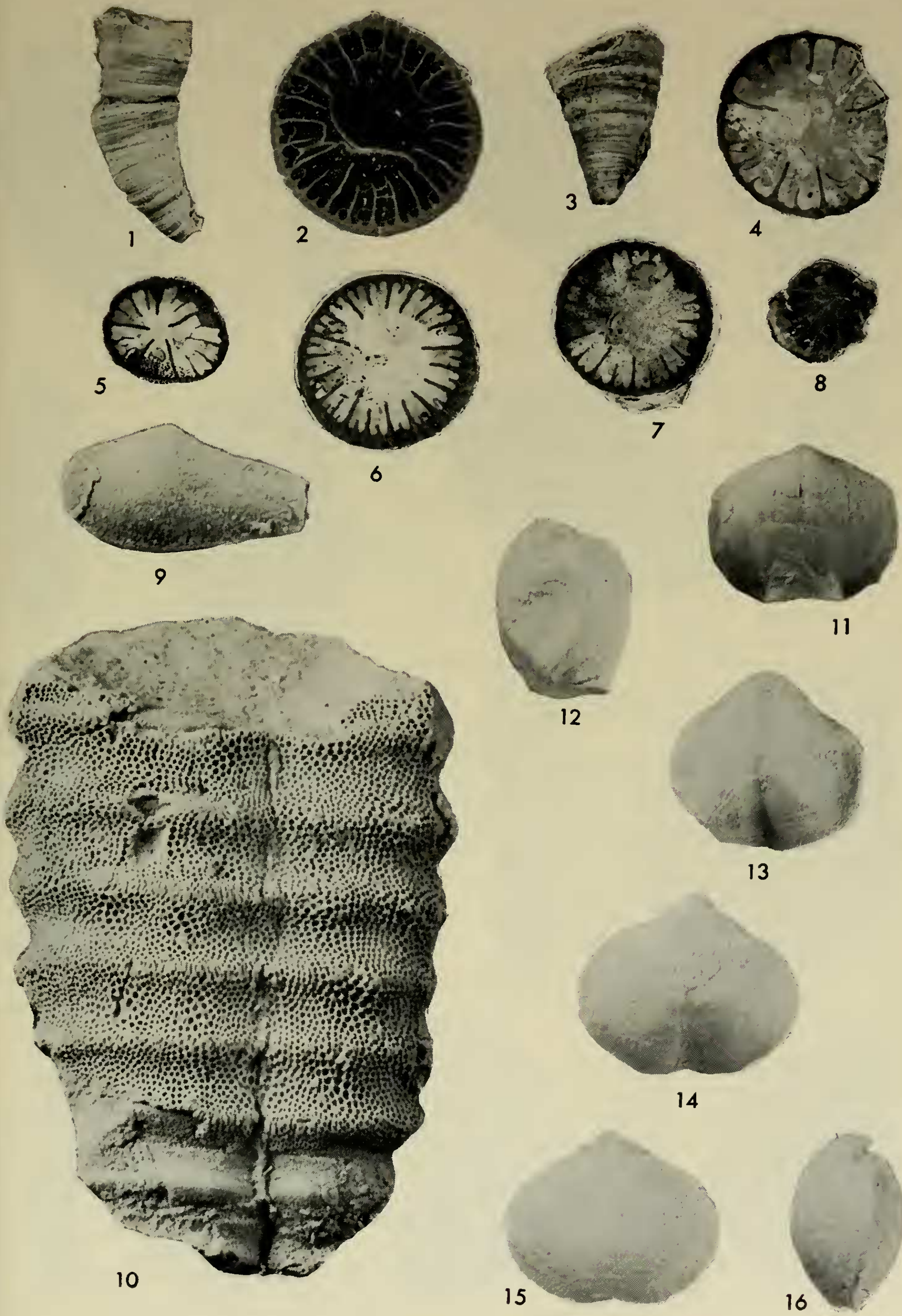
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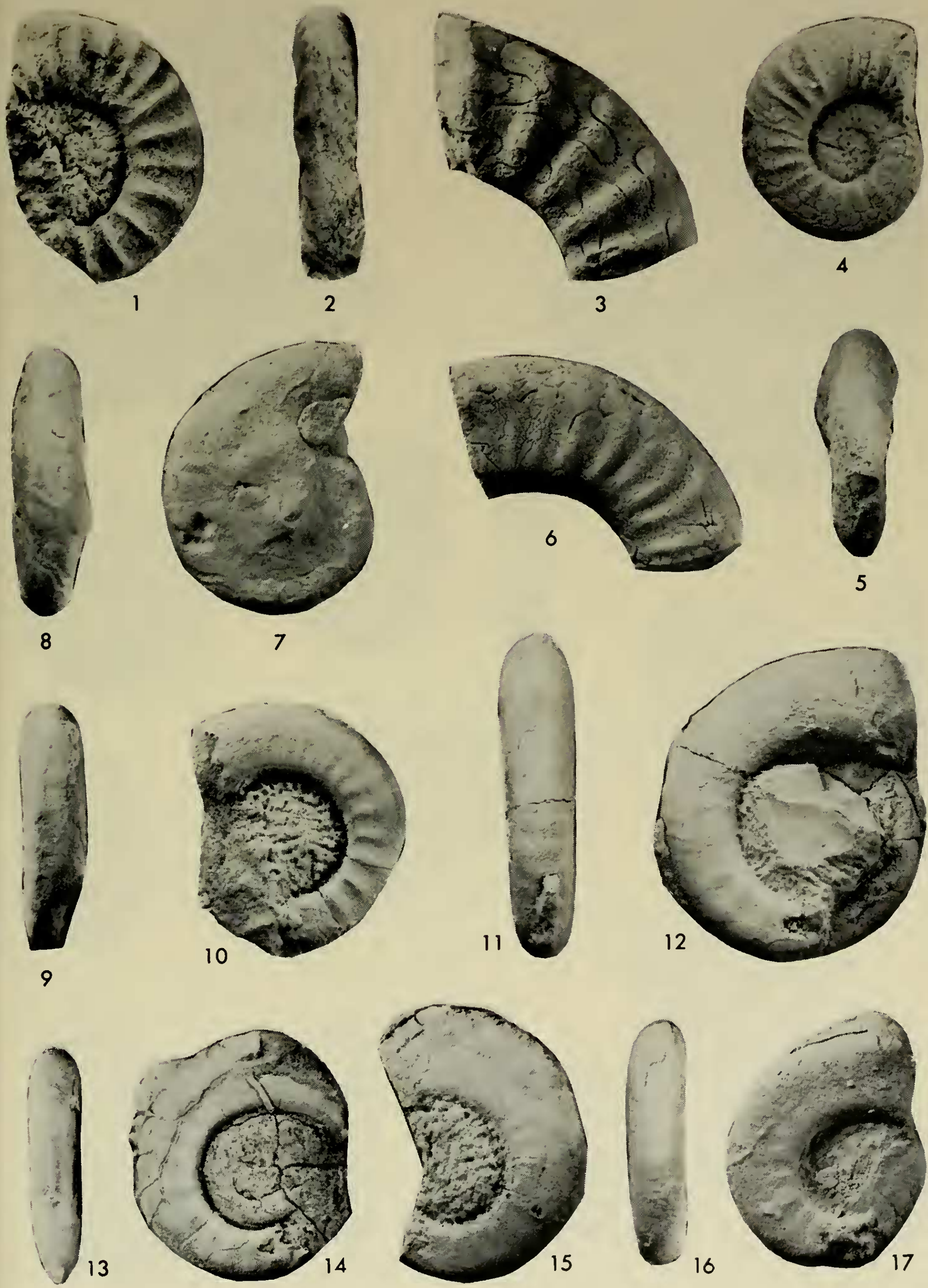
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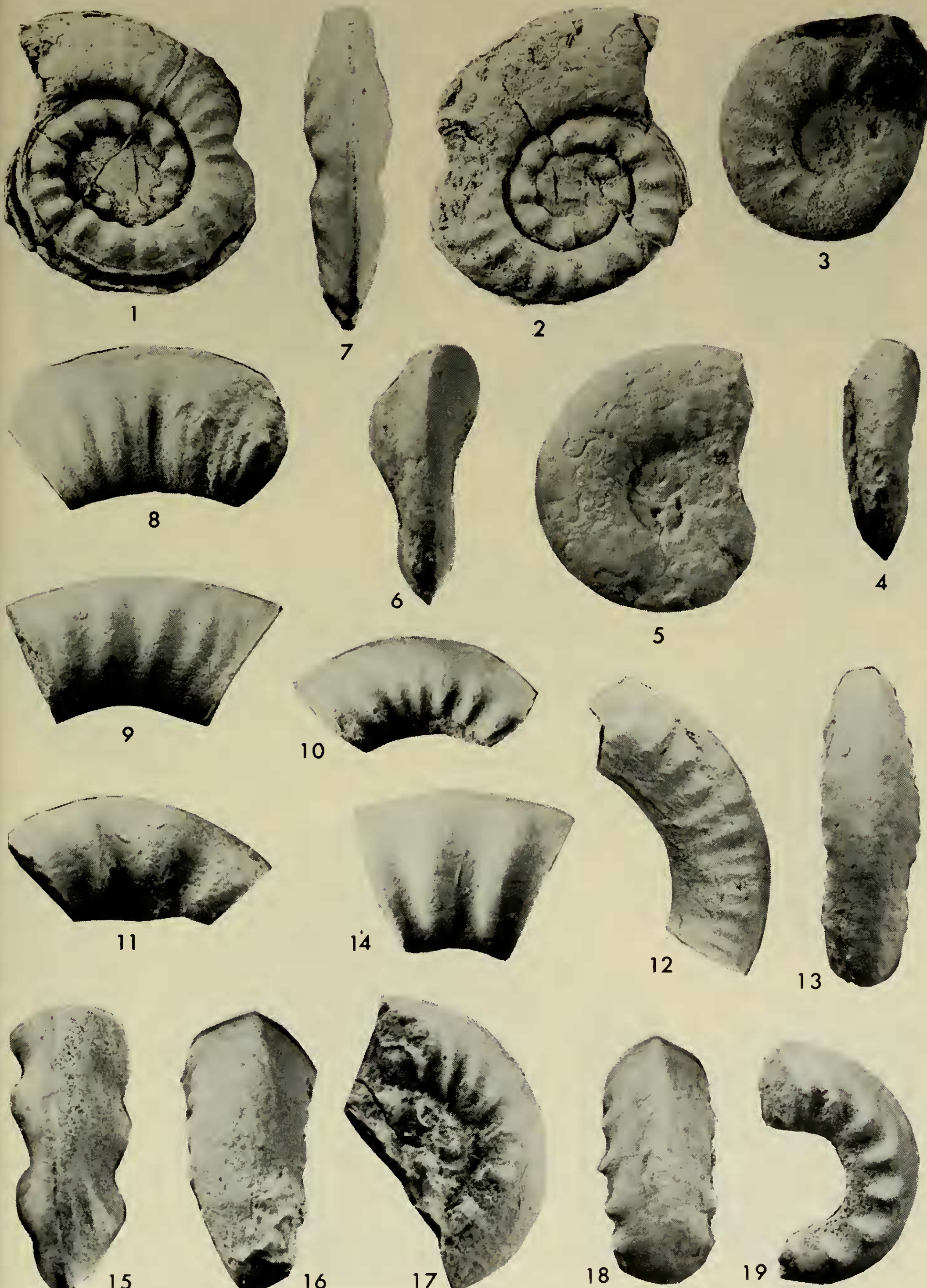
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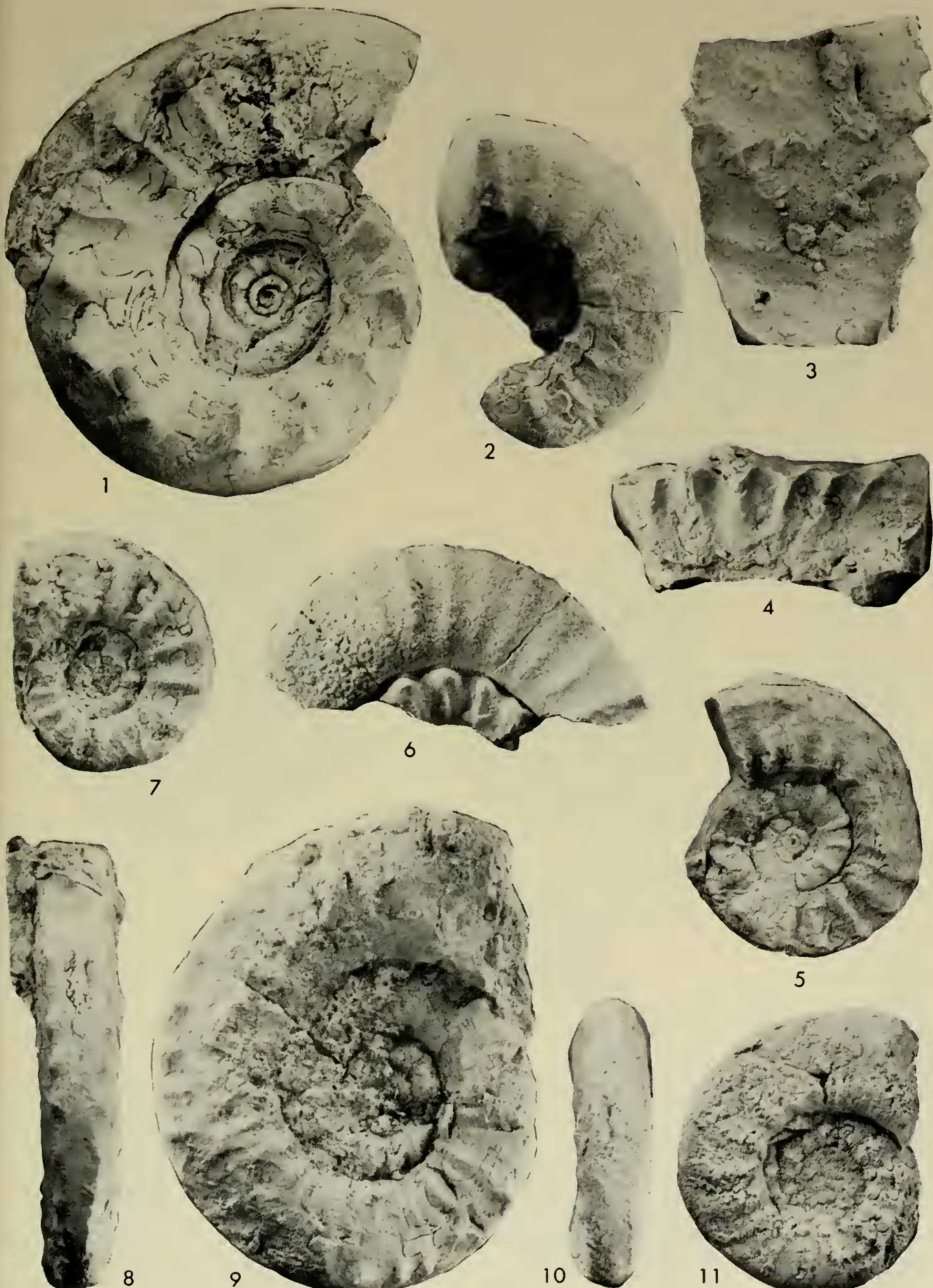

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Plate 8. PHISONITES, LIROCERAS, DOMATOCERAS


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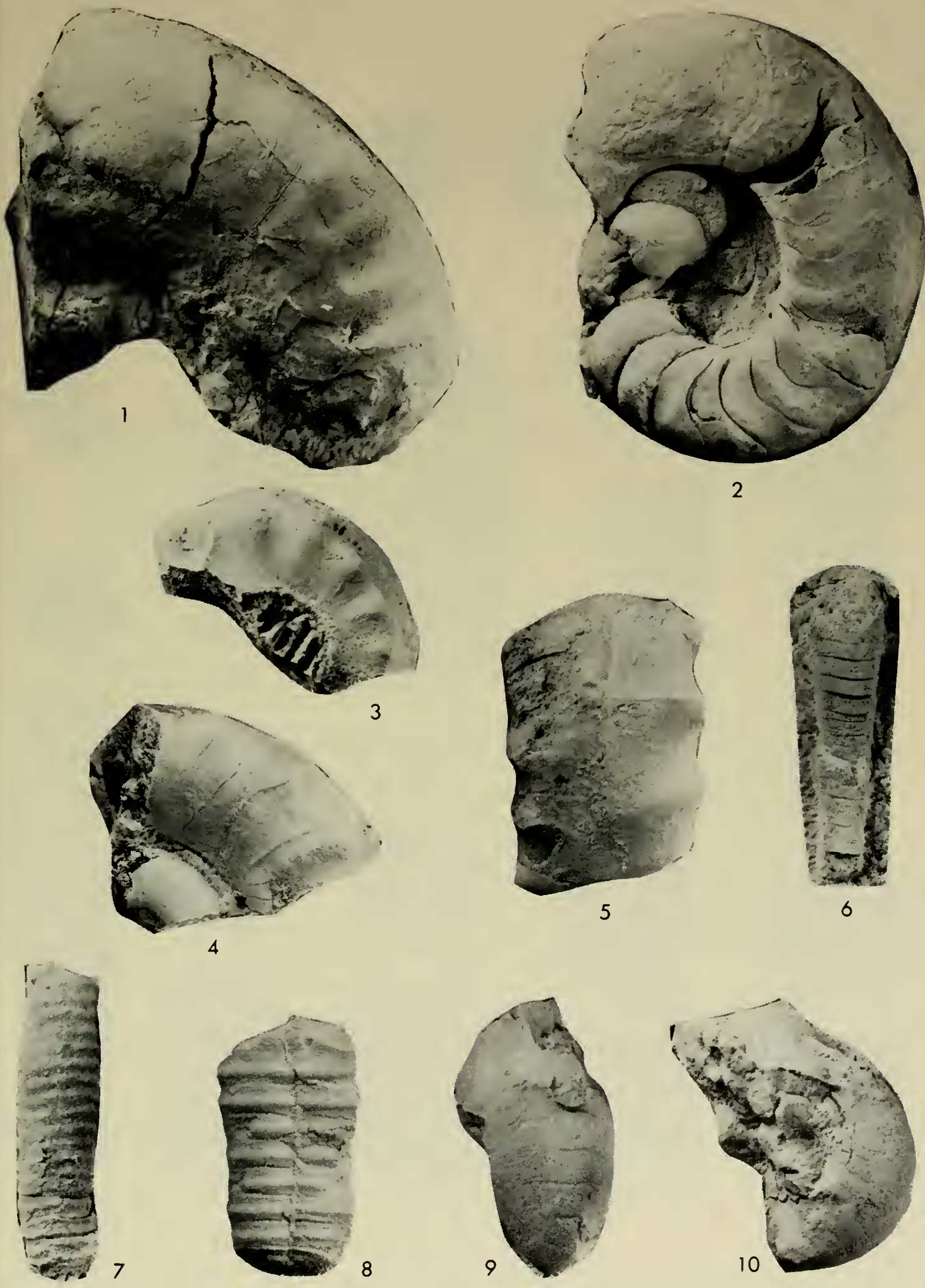
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Plate 10. ERISOCRINUS; crinoid stems, order and family uncertain

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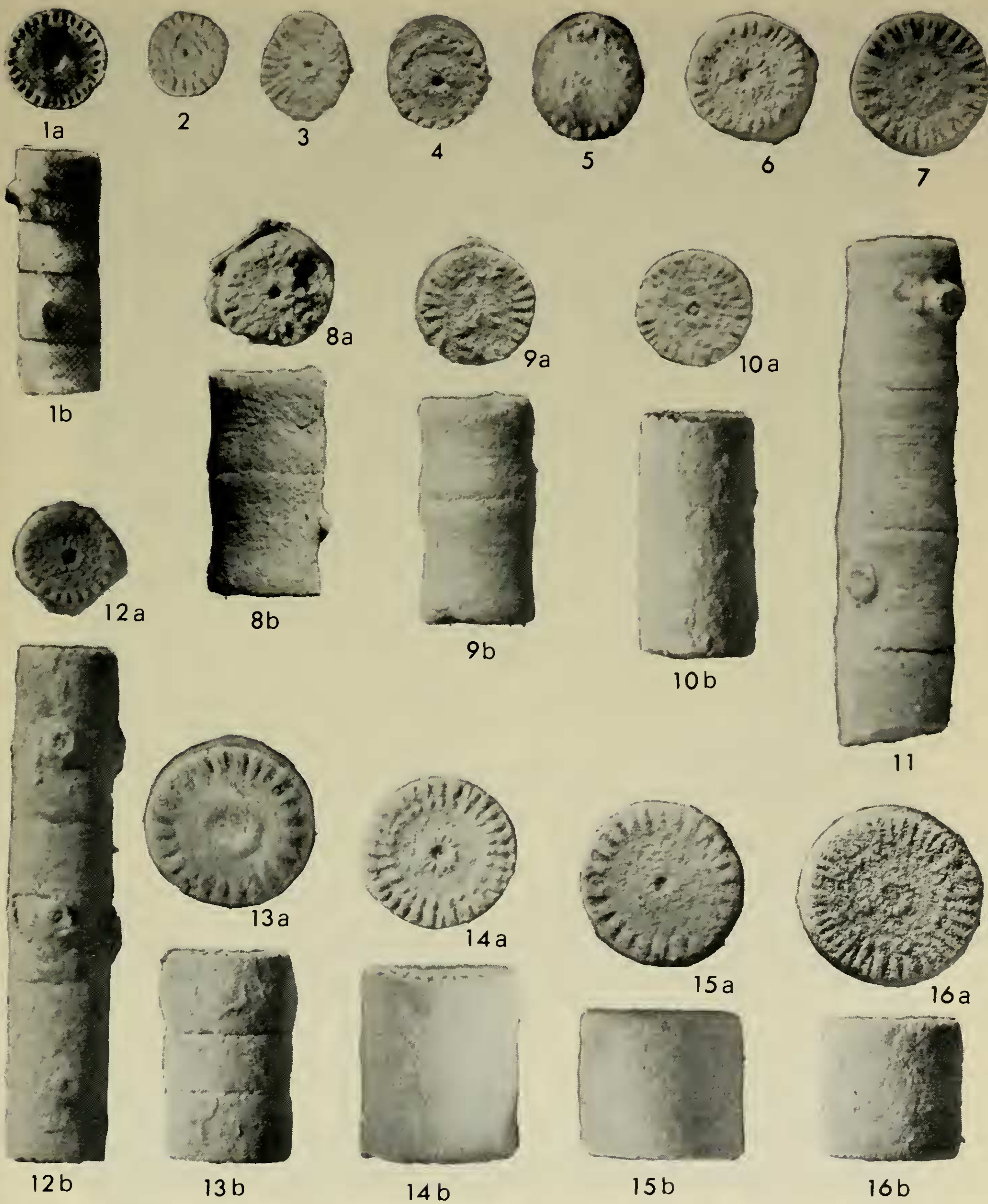
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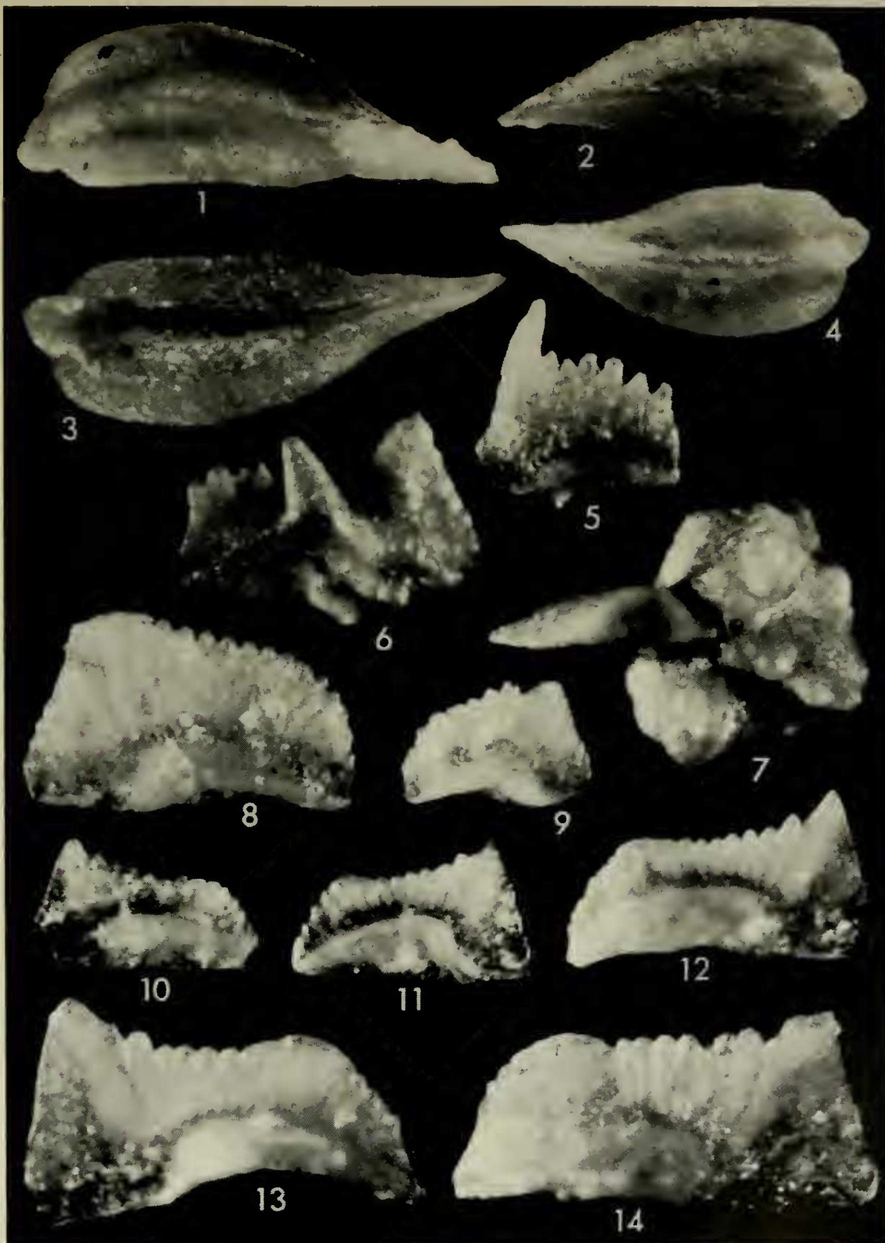
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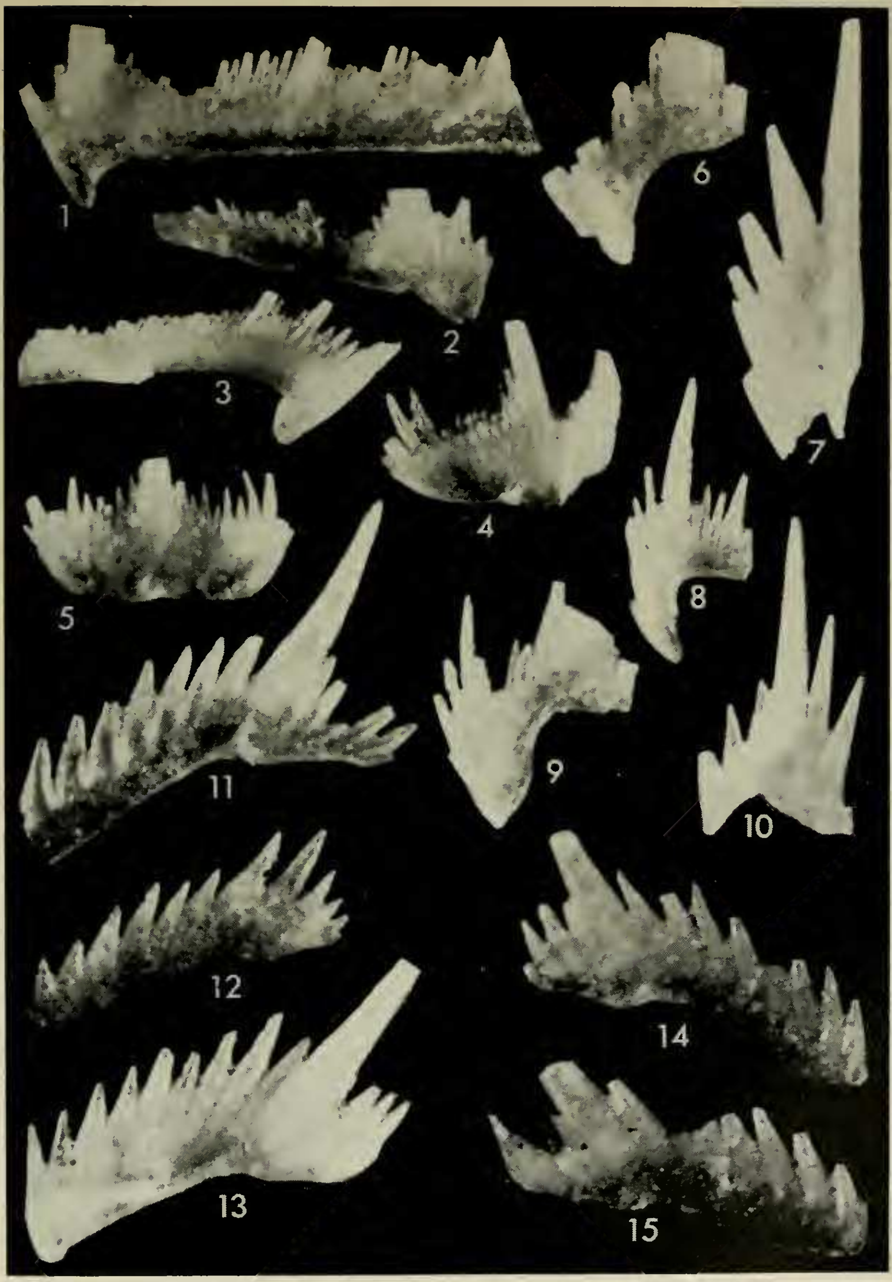
Plate 12. ELLISONIA, XANIOGNATHUS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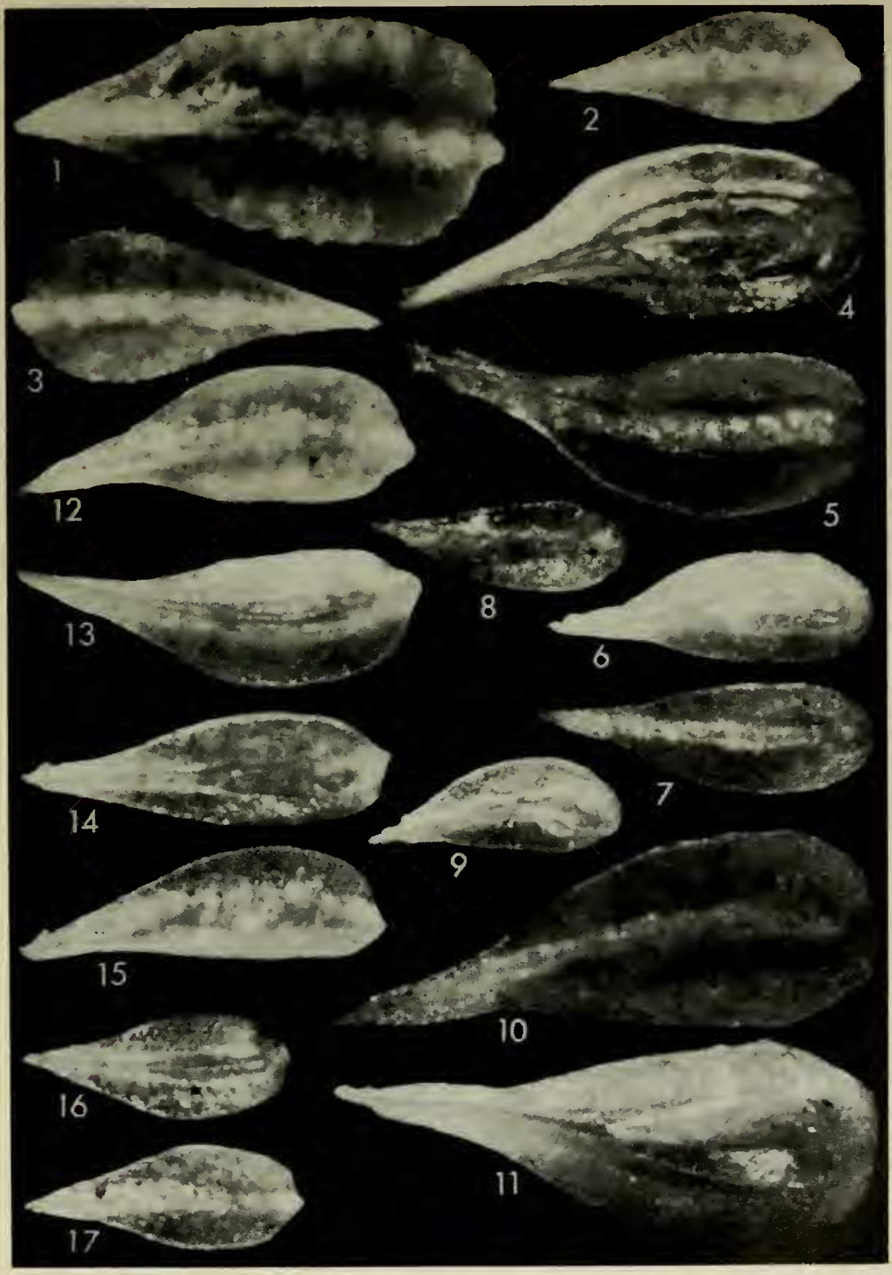
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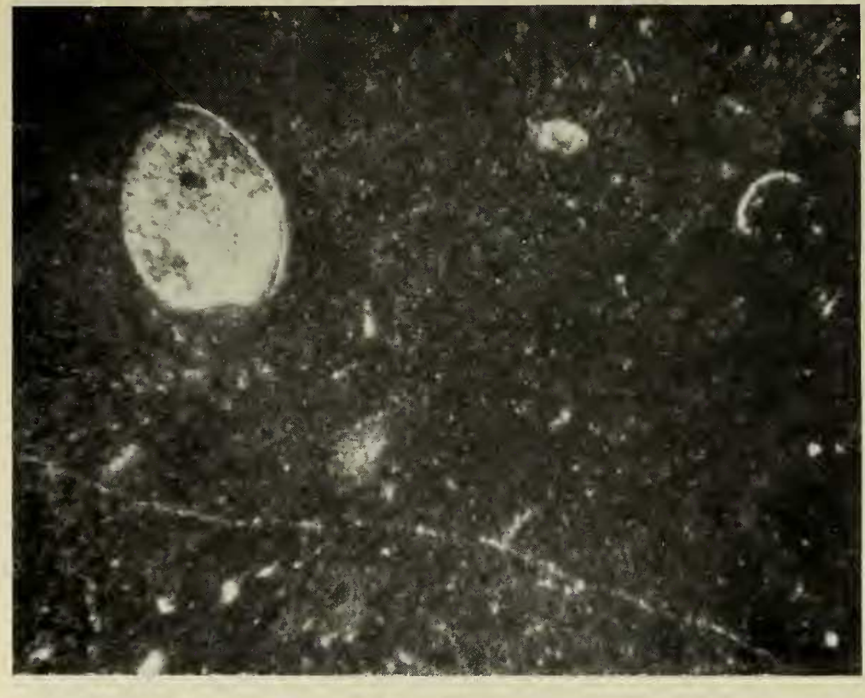

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